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# NON-CELIAC GLUTEN SENSITIVITY: A TRADITIONAL REVIEW

# NON-ÇÖLYAK GLUTEN HASSASİYETİ: GELENEKSEL BİR DERLEME

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**Abstract**
Non-celiac gluten sensitivity (NCGS) is a disorder characterized by gastrointestinal and extra-intestinal symptoms caused by the consumption of gluten-containing foods in individuals who do not have celiac disease or wheat allergy. The limited knowledge regarding NCGS has led to various challenges in diagnosis and disease management. Due to the lack of sensitive and reproducible biomarkers for diagnosis, current evidence on NCGS prevalence is primarily based on survey studies. Although it is believed that both innate and adaptive immune systems play a role in the pathogenesis of NCGS, this remains an area of uncertainty. A gluten-free diet is recommended as the best treatment method for symptom control in NCGS. However, the gluten-free diet may lead to deficiencies in certain macro and micronutrients, and thus should be followed under the supervision of a nutritionist and clinician. With the continuously evolving body of knowledge, significant progress has been made in understanding the perspective on NCGS. The aim of this review is to provide a comprehensive overview of the etiopathogenesis, clinical features, and treatment of NCGS considering the most recent data.

**Keywords:** Diagnose, Epidemiology, Gluten-free diet, Non-celiac gluten sensitivity

**Öz**
Non-çölyak gluten hassasiyeti (NCGS), çölyak hastalığı veya buğday alerjisi olmayan bireylerde, gluten içeren besinlerin tüketimi ile gastrointestinal ve ekstraintestinal semptomlara neden olan bir bozukluktur. NCGS'ye ilişkin bilgilerin oldukça sınırlı olması, tanı koymada ve hastalık yönetiminde çeşitli zorluklara neden olmaktadır. Tanı için duyarlı ve tekrarlanabilir biyobelirteçlerin eksikliği nedeni ile NCGS prevalansını belirlenmeye yönelik mevcut kanıtlar anket çalışmalarına dayanmaktadır. NCGS patogenezinde doğuştan gelen ve adaptif bağışıklık sisteminin etkili olduğu düşünülmekle birlikte bu durum henüz netliğe kavuşturulmamıştır. NCGS'de semptomların kontrolü için en iyi tedavi yöntemi olarak glutensiz diyet önerilmektedir. Glutensiz diyet, bazı makro ve mikro besin ögelerinde eksikliklere neden olabilir bu nedenle beslenme uzmanı ve klinisyen kontrolünde yürütülmelidir. Sürekli güncellenen bilgiler ile NCGS'ye ait bakış açısında ilerleme kaydedilmektedir. Bu derleme çalışmasının amacı ise güncel bilgiler ışığında NCGS'nin etiyopatolojisi, klinik özelliklerinin daha iyi anlaşılması ve tedavisine yönelik genel bir bakış açısı sunmaktır.

**Anahtar Kelimeler:** Tanı, Epidemiyoloji, Glutensiz diyet, Non-çölyak gluten hassasiyeti

## 1. Definition and clinical features of non-celiac gluten sensitivity

Gluten-related disorders encompass allergic reactions, autoimmune diseases (such as dermatitis herpetiformis, gluten ataxia, and celiac disease), and, more recently, the increasingly reported condition known as non-celiac gluten sensitivity (NCGS). The earliest descriptions of gluten sensitivity were made in the literature in the 1980s (Cooper et al., 1980). A panel of experts was subsequently convened in London in February 2011 to build consensus on a new nomenclature and classification of gluten-related disorders. After this panel, NCGS emerged as a new definition to avoid confusion with celiac disease, which is defined as gluten-sensitive enteropathy (Sapone et al., 2012). These disorders, which are

prevalent worldwide, significantly reduce individuals' quality of life (Miranda et al., 2023).

NCGS is a condition characterized by various symptoms triggered by the consumption of gluten-containing foods in individuals without celiac disease or wheat allergy. In addition to gastrointestinal symptoms, extraintestinal manifestations can also occur in individuals with NCGS (Sürmeli & Karabudak, 2019). Typically, symptoms begin shortly after the consumption of gluten-containing foods, decrease or disappear upon gluten withdrawal, and reappear with gluten reintroduction (Barbaro et al., 2020). The most common symptoms of NCGS include abdominal pain, bloating, changes in bowel habits, fatigue, headache, brain fog, anxiety, joint and muscle pain, and numbness in the legs or arms (Barbaro et al., 2020; Cárdenas-Torres et al., 2021). Studies based on self-reported data from individuals with NCGS indicate that gastrointestinal symptoms are more prevalent than extraintestinal ones (Mansueto et al., 2019; Potter et al., 2020; Cárdenas-Torres et al., 2021). NCGS has been reported to occur more frequently in women than men and in young to middle-aged individuals compared to other age groups. Autoimmune diseases are present in 24–25.3% of individuals diagnosed with NCGS, with autoimmune thyroid disease being the most common, observed in 69.5–100% of cases (Cárdenas-Torres et al., 2021).

## 2. Epidemiology of non-celiac gluten sensitivity

Due to its relatively recent recognition and the absence of sensitive and reproducible biomarkers for diagnosis, the global prevalence of NCGS remains unknown. Epidemiological studies have estimated the prevalence of NCGS based on self-reported data (Vasagar et al., 2017). These studies have identified three criteria for diagnosing NCGS: the presence of discomfort or adverse reactions following the consumption of gluten-containing foods, the absence of a physician-diagnosed celiac disease or wheat allergy, and adherence to a gluten-free diet (Cárdenas-Torres et al., 2021).

Although these studies rely on self-reported data rather than objective tests to exclude celiac disease and wheat allergy, which is a limitation, they provide a foundation for further epidemiological research. In Western populations, the prevalence of NCGS has been reported to range from 0.6% to 10.6% (Shahbazkhani et al., 2020).

## 3. Pathogenesis of non-celiac gluten sensitivity

While the pathogenesis of NCGS remains unclear, evidence suggests a role for the innate immune system. Compared to healthy individuals and those with celiac disease, intestinal biopsies from individuals with NCGS show increased expression of toll-like receptor 2 (TLR2) and decreased expression of FOXP3 (forkhead box P3), a member of the FOX protein family (Shahbazkhani et al., 2020). Elevated levels of interleukin (IL)-10, transforming growth factor (TGF)-α, granulocyte-macrophage colony-stimulating factor (GM-CSF), and lipopolysaccharide (LPS)-binding protein have been observed in individuals with wheat sensitivity, even in the absence of celiac disease (Cárdenas-Torres et al., 2021).

The detection of RNA transcripts involved in the activation of the innate immune system, such as azurocidin 1 (AZU1), bone morphogenetic protein-7 (BMP7), and cluster of differentiation 70 (CD70), in the intestinal mucosa of individuals with NCGS underscores the dominant role of innate immunity (Efthymakis et al., 2020). Furthermore, approximately half of individuals with NCGS exhibit anti-gliadin antibodies, and elevated levels of tumor necrosis factor (TNF)-α and IL-17 compared to healthy controls suggest a potential involvement of the adaptive immune system as well (Mansueto et al., 2020).

Increased eosinophils, intraepithelial CD3+ T cells, lamina propria CD45+ cells in the duodenum and rectal tissues, and mast cells in the duodenum of NCGS patients have been linked to intestinal inflammation (Cárdenas-Torres et al., 2021). Additionally, an increased percentage of cells expressing cytokines that induce and sustain Th1 and Th17 responses, such as IL-12, IL-15, and IL-2, as well as those expressing TNF-α and IL-1β, highlights the simultaneous roles of both innate and adaptive immune systems in NCGS (Castillo-Rodal et al., 2020).

Changes and dysfunction in the intestinal barrier in individuals with NCGS stimulate immune responses by facilitating the activation of both innate and adaptive immune systems through the translocation of microbial products (Uhde et al., 2016). Although the specific triggering role of gluten remains unclear, it has been suggested that the pathogenesis of NCGS may be multifactorial. Gluten has been reported to induce the release of zonulin, which increases intestinal permeability and allows the passage of molecules from the intestinal epithelium to the lamina propria. Gliadin peptides, upon entering the lamina propria, activate the innate immune system via TLR-2 and TLR-4 receptors, inducing the release of pro-inflammatory cytokines (Herrera et al., 2018).

Amylase/trypsin inhibitors (ATIs), resistant to gastrointestinal proteases and found in the endosperm of plant seeds, have been implicated in NCGS pathophysiology, although their exact role remains uncertain. ATIs are known to activate the innate immune system by triggering the nuclear factor kappa-B (NF-κB) pathway, which leads to the release of pro-inflammatory cytokines such as IL-8, IL-15, TNF-α, and monocyte chemoattractant protein-1 (MCP-1) by dendritic cells, macrophages, and monocytes. Intestinal barrier dysfunction may allow

ATIs to reach the lamina propria and interact with immune cells, thereby exacerbating the release of pro-inflammatory cytokines (Zevallos et al., 2017).

**4. Diagnostic process of non-celiac gluten sensitivity**

There are no specific biochemical, immunological or histopathological markers associated with NCGS (Al-Toma et al., 2019). The diagnosis of NCGS is considered in patients with persistent intestinal complaints where celiac disease and wheat allergy biomarkers are normal, yet various symptoms are triggered by consuming gluten-containing foods (Roszkowska et al., 2019). Symptoms in NCGS typically begin immediately after gluten intake and resolve upon gluten withdrawal from the diet. And most of these patients are already on a gluten-free diet (GFD) when they are first seen in a specialised clinic. Due to its similarity to symptoms of irritable bowel syndrome (e.g., headache, fatigue, muscle pain), diagnosing NCGS is challenging, especially in the absence of sensitive and specific biomarkers (Barbaro et al., 2018; Sürmeli & Karabudak, 2019). A multi-step approach is recommended by the Salerno Expert Criteria to diagnose NCGS (Catassi et al., 2015).

- In the first stage, a clinical and laboratory evaluation should be performed to exclude celiac disease and wheat allergy when consuming a GFD. If celiac disease is suspected, a duodenal biopsy can be performed and if Marsh (0-1), i.e. the risk of celiac disease is low, basic symptoms should be determined while the patient is on a gluten-containing diet, GFD should be monitored for at least 6 weeks and symptoms should be reassessed. Additionally, the modified version of the Gastrointestinal Symptom Rating Scale (GSRS) can be employed for symptom assessment (Kulich et al., 2008). Non-celiac gluten sensitivity is excluded in individuals who do not show improvement in symptoms.

-In the second stage, a clinical evaluation is performed with single or double-blind placebo-controlled gluten loading tests. Gluten loading is necessary in patients responding to GFD therapy and in individuals who were on GFD prior to testing. Whether this should be done by the addition of gluten or by some other means that excludes FODMAP is a matter of debate. Ideally, specific laboratory tests should be repeated serially in clinical evaluations. According to the Salerno Expert Criteria, approximately 40% of individuals with suspected NCGS exhibit a direct relationship between gluten challenge and symptom exacerbation (Lionetti et al., 2017).

Due to the wide variety of clinical symptoms associated with NCGS, it is recommended that diagnostic criteria include negative endomysial antibody (EMA) and anti-tissue transglutaminase (anti-tTG) antibody results, no mucosal abnormalities on small intestinal biopsy, or findings consistent with Marsh grade 0/1 (Sümer et al., 2015). Specific immunoglobulin E (IgE) testing and skin prick testing should be performed to exclude wheat allergy, with no detectable specific IgE antibodies expected. Additionally, an appropriate screening for celiac disease must precede the diagnosis of NCGS. Patients diagnosed with NCGS have been found to have positive antigliadin antibody IgG and IgA levels, although these levels are significantly lower compared to those in celiac disease patients (Uhde et al., 2020). Human leukocyte antigen (HLA) DQ2/DQ8 haplotypes, commonly associated with celiac disease, are present in approximately 50% of NCGS patients, whereas this prevalence exceeds 95% in celiac disease cases (Mansueto et al., 2019). These biomarkers are critical for accurately distinguishing NCGS from celiac disease and wheat allergy. Furthermore, the intensity of symptoms in NCGS is typically lower than in celiac disease or wheat allergy, and symptoms tend to resolve more quickly (Cabanillas, 2020). Symptoms such as bloating, abdominal pain, and altered bowel habits, observed in irritable bowel syndrome (IBS), may also occur in NCGS. However, while triggers in NCGS include gluten, amylase/trypsin inhibitors (ATIs), and FODMAPs, IBS can involve a broader range of dietary triggers beyond gluten-containing grains (Rinninella et al., 2019). Small intestinal biopsies from patients with NCGS often appear normal or show mild inflammation. Table 1 compares gluten-related disorders, highlighting their key distinctions. In addition, the European Society for the Study of Coeliac Disease (ESsCD) has recommendations on the diagnosis and management of NGCS and celiac disease (Al-Toma et al., 2019).

1. The presence of NCGS should be considered in patients with gluten-related intestinal and/or extraintestinal complaints and normal results of celiac disease and wheat allergy serological markers on a gluten-containing diet (Strong recommendation, moderate level of evidence).
2. Serology and small bowel histology (when the patient is on a gluten-containing diet) and HLA-DQ typing are necessary to differentiate between celiac disease and NCGS (Strong recommendation, moderate level of evidence).
3. The diagnosis of NCGS is excluded in patients who do not show symptomatic improvement after six weeks of GFD (Strong recommendation, moderate level of evidence).
4. A less-strict GFDs are sufficient in individuals with NCGS compared with individuals with celiac disease (Conditional recommendation, low level of evidence).
5. Other possible causes of IBS-like symptoms should be investigated in patients with a negative gluten test (Conditional recommendation, low level of evidence).

**Table 1.** Comparison of gluten-related disorders (Cárdenas-Torres et al., 2021)

| Characteristic | Non-Celiac Gluten Sensitivity | Celiac Disease | Wheat Allergy |
|---|---|---|---|
| **Trigger** | Gluten, ATIs, FODMAPs | Gluten | Wheat proteins |
| **Prevalence** | 0.49–14.9% | 1% | 1% |
| **Pathogenesis** | Predominantly innate immunity | Autoimmune | IgE-mediated allergic reaction |
| **HLA DQ2/DQ8** | 50% carry HLA DQ2/DQ8 haplotypes | >95% carry HLA DQ2/DQ8 haplotypes | No HLA DQ2/DQ8 restriction |
| **Serological markers** | Lack of serological biomarkers (50% IgG AGA positive) | IgA EMA, IgA tTG, IgG DGP | IgE to wheat proteins |
| **Histology** | Marsh 0 to 1 | Marsh 1 to 4 | Normal |
| **Symptom types** | Intestinal and extra-intestinal | Intestinal and extra-intestinal | Intestinal and extra-intestinal |
| **Symptom onset** | Within hours to days | Within days to weeks | Within minutes to hours |
| **Symptom intensity** | Mild | Low to high | Low to high |
| **Complications** | Unknown | Long-term complications | Anaphylaxis |
| **Diagnosis** | Double-blind placebo-controlled gluten challenge | HLA DQ2/DQ8, antibodies, biopsy | IgE to wheat, skin prick test |
| **Treatment** | Gluten-free diet, low-FODMAP diet | Gluten-free diet | Wheat-free diet |
| **Duration of treatment** | Unknown | Lifelong | Lifelong |

ATI: Amylase-trypsin inhibitors; FODMAPs: Fermentable oligo-, di-, monosaccharides, and polyols; AGA: Anti-gliadin antibodies; DGP: Deaminated gliadin peptides; EMA: Endomysial antibodies; tTG: Tissue transglutaminase.

## 5. Dietary Treatment in Non-Celiac Gluten Sensitivity

Fermentable oligosaccharides, disaccharides, monosaccharides, and polyols (FODMAPs), have been implicated in triggering symptoms associated with various gastrointestinal disorders, including NCGS. Studies suggest that a low-FODMAP diet may help alleviate NCGS symptoms (Bellini et al., 2020). FODMAPs are fermented by gut bacteria, increasing luminal water content and gas production, which can lead to intestinal distension. This distension activates intestinal mechanoreceptors and the enteric nervous system, potentially contributing to neuropsychiatric symptoms (Khan et al., 2020). However, the specific role of FODMAPs and other grain components in the pathophysiology of NCGS remains unclear (Fernandes Dias et al., 2023).

A gluten-free diet is recommended for individuals with NCGS. However, unlike celiac disease, it has not yet been clarified whether a lifelong gluten-free diet is necessary (Serena et al., 2020). A study reported that 74% of individuals with NCGS continued to follow a gluten-free diet 8 years after diagnosis, and symptoms worsened with the consumption of gluten-containing foods (Carroccio et al., 2017). In a gluten-free diet, gluten, a protein found in grains such as wheat, barley, and rye, is completely removed from the diet. While oats are not thought to trigger an immune response, they can become contaminated with gluten if processed or grown in the same area as wheat, barley, or rye (Sürmeli & Karabudak, 2019; Husby et al., 2020).

Therefore, oats that are specially cultivated, processed, and packaged as gluten-free are considered safe for NCGS patients. There is no tolerance threshold for gluten or wheat in individuals with NCGS (Pinto-Sánchez et al., 2017). Products such as sauces, ready-made soups, ice cream, sausages, candies, desserts, and fruit nectars, even if initially produced as gluten-free, may become contaminated with gluten. Therefore, gluten-free diets should ideally be based on naturally gluten-free and minimally processed foods (Cárdenas-Torres et al., 2021). Information on gluten-containing and gluten-free foods is provided in Table 2. To be considered gluten-free, a food must contain less than 20 ppm/kg or 20 mg/kg of gluten. This threshold is recognized by international authorities, and foods labeled as gluten-free must not exceed 20 ppm of gluten (Wieser et al., 2021). Gluten-free foods can be identified by labels that state "gluten-free" or display a logo indicating that they are gluten-free, or by statements confirming that the product does not contain gluten (Thompson & Simpson, 2015; Serena et al., 2020). Despite patients' efforts to avoid gluten and manufacturers' efforts to produce gluten-free foods, adhering to a strict gluten-free diet is quite challenging.

**Table 2.** Gluten-containing and gluten-free foods (Presutti et al., 2007)

| | Gluten-Containing | Gluten-Free |
|---|---|---|
| **Cereals** | Barley, bulgur, rye, wheat-based semolina, bread or pasta containing wheat or wheat bran, cereals made with wheat, rye, or barley, or cereals containing malt extract or malt flavor, non-pure gluten-free oats | Arrowroot, corn, buckwheat, cornmeal, corn grits, millet, potato starch, rice, rice bran, starch, soy, popcorn, white or brown rice, pure gluten-free oats, quinoa |
| **Vegetables and Legumes** | Creamed or breaded vegetables, some types of fried potatoes, canned baked beans | Fresh, frozen, or canned vegetables, soybeans |
| **Fruits** | Some commercial fruit pie fillings and dried fruits | All fruits |
| **Dairy Products** | Malted milk, some dairy beverages, and flavored or frozen yogurts | Dairy products and milk without gluten additives |
| **Meat, Poultry, Fish, Shellfish, Eggs, and Nuts** | Some deli products, sausages, sandwich spreads, and canned meats made with barley, oats, rye, wheat, or gluten-based stabilizers or fillers | Unseasoned meats, poultry, fish, and shellfish; deli products, sausages, sandwich spreads without gluten fillers, eggs, nuts, and peanut butter |
| **Snacks and Sauces** | Many commercial salad dressings, instant soups, sauces, and condiments | Butter, margarine, honey, jam, jelly, molasses, sugar, coconut, hard candies, plain chocolate |
| **Beverages** | Flavored instant coffees, herbal teas, instant hot chocolate mixes, non-dairy creamers | Pure, instant, or ground coffee; tea, carbonated beverages, fruit juices |

*5.1. Challenges in implementing gluten-free diets*

Applying a gluten-free diet is quite challenging, and patients may unknowingly be exposed to gluten (Rubio-Tapia et al., 2010). A significant portion of celiac disease patients on a gluten-free diet have shown no improvement in intestinal mucosa, and at least 30% of patients experience persistent intestinal symptoms. It has been noted that unknowingly being exposed to gluten may be associated with these issues (Penny et al., 2020).

Adherence to gluten-free diets can cause social and economic difficulties, particularly when eating outside the home, and can negatively affect individuals' quality of life (Penagini et al., 2013). Additionally, it can create further challenges for adolescent patients who seek to avoid social exclusion in environments like school. Moreover, the low nutritional quality of gluten-free packaged foods may lead to certain nutritional problems (Barbaro et al., 2018).

*5.2. Nutritional concerns in gluten-free diets*

While gluten-free diets improve the clinical symptoms of NCGS, they can also lead to some nutritional concerns. Generally, gluten-free diets are low in complex carbohydrates and proteins, while being high in fats and simple carbohydrates. Because gluten-free packaged foods tend to be higher in energy compared to their gluten-containing counterparts, individuals may experience weight gain when transitioning to a gluten-free diet (Amirikian et al., 2019; Cárdenas-Torres et al., 2021; Vereczkei et al., 2023).

*5.3. Nutritional concerns related to macronutrient intake*

Fruits, vegetables, and whole grain foods are rich in both complex carbohydrates and fiber. As a result, they play a key role in regulating intestinal motility, promoting satiety, and improving blood glucose and lipid profiles. Gluten-free diets, depending on the type of flour and starch used, lead to high carbohydrate and sugar intake while causing a low fiber intake (Cardo et al., 2021).

The quality of dietary fat (saturated, unsaturated fatty acids) is as important as the quantity of fat in the diet. It has been reported that gluten-free packaged foods tend to be high in saturated and hydrogenated fats (Wu et al., 2015). Since dietary fat provides more energy compared to other macronutrients, switching to a gluten-free diet may result in weight gain. Furthermore, an increase in saturated fat intake in individuals on gluten-free diets has been linked to a higher risk of cardiovascular disease (Vici et al., 2016; Niland & Cash, 2018; Ciccone et al., 2019; Motazedian et al., 2023).

Generally, the percentage of energy derived from protein in a gluten-free diet is reported to be lower (Larretxi et al., 2019). A systematic review and meta-analysis have found that gluten-free foods are lower in protein content (Melini & Melini, 2019). This is concerning, as proteins provide multiple benefits such as enhancing satiety, supporting thermogenesis, and preserving muscle mass (Penagini et al., 2013).

*5.4. Nutritional concerns related to micronutrient intake*

Celiac disease is an autoimmune disease triggered by gluten in which small intestinal enteropathy is observed in individuals with genetic predisposition (positive for HLA-DQ2/HLA-DQ8 alleles) and histologically villous atrophy, crypt hyperplasia and enteropathy caused by increased intraepithelial

lymphocytes in duodenal biopsies are observed (Catassi et al., 2022). Non-celiac gluten sensitivity is considered a clinical disorder characterised by gastrointestinal and extra-intestinal symptoms caused by wheat and/or gluten-containing foods. Unlike celiac disease, there is no specific test to test NCGS, leading to a lack of understanding of its pathophysiology (Abdi et al., 2023). Gluten ingestion does not cause enteropathy or malabsorption in NCGS, but only gastrointestinal and extraintestinal symptoms such as abdominal pain, diarrhoea, constipation, bloating, headache and brain fog (Skodje et al., 2018). While the only available treatment for celiac disease is a GFD, adherence to a GFD is also recommended in patients with NCGS (Abdi et al., 2023). Individuals with active celiac disease may experience deficiencies in micronutrients such as iron, vitamin B12 and folate due to malabsorption resulting from villous atrophy (Martín-Masot et al., 2019). Additionally, impaired fat absorption can lead to decreased levels of fat-soluble vitamins (Jivraj et al., 2022). However, micronutrient deficiencies can also occur in individuals following a gluten-free diet, suggesting that nutrient deficiencies are not solely associated with malabsorption issues. Limited food options and the lack of fortification in gluten-free products have been identified as key factors contributing to micronutrient deficiencies in gluten-free diets (Di Nardo et al., 2019). It has been reported that gluten-free products have particularly low levels of folate and iron (Martín-Masot et al., 2019). Studies have shown that individuals on a gluten-free diet tend to consume lower amounts of folic acid, vitamin C, vitamin B12, magnesium, zinc, and iron (Vici et al., 2016; Niland & Cash, 2018; Melini & Melini, 2019). Since naturally gluten-free foods such as fruits, vegetables, meat, poultry, and fish contain essential vitamins and minerals, the consumption of these foods by individuals with NCGS may help prevent micronutrient deficiencies. However, if deficiencies do occur, healthcare professionals may recommend dietary supplements.

## 6. Conclusion

The limited knowledge regarding NCGS poses various challenges in diagnosis and disease management. The lack of sensitive and reproducible biomarkers for diagnosing NCGS, along with the absence of a sufficient diagnostic approach for clinical practice, complicates the determination of NCGS prevalence. Current evidence on prevalence relies on survey studies related to NCGS. Although it is believed that both innate and adaptive immune systems play a role in the pathogenesis of NCGS, this remains unclear. A gluten-free diet is recommended as the best treatment method for controlling symptoms in NCGS. However, gluten-free diets may lead to deficiencies in some macro- and micronutrients, and therefore, should be implemented under the supervision of a nutritionist and clinician.

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