

Systematic Review

Attitudes, Behaviors, and Perceptions Toward Gluten-Free Food Labeling in Gluten-Related Diseases: A Systematic Review and Meta-Analysis

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Abstract

Gluten-related diseases (GRDs), affecting approximately 1–6% of the global population, require long-term adherence to a gluten-free (GF) diet for effective disease management. Food label literacy plays a critical role in ensuring dietary safety; however, consumer attitudes, behaviors, and perceptions regarding GF food labeling remain insufficiently characterized. This study systematically reviewed and synthesized evidence on these factors across different GRDs. A comprehensive search of PubMed/MEDLINE, EMBASE, Cochrane Library, Scopus, and Web of Science was conducted for studies published between January 2000 and December 2025. Studies evaluating attitudes, beliefs, and behaviors related to GF food labeling among individuals with GRDs were included. A total of 82 studies involving 61,284 participants from 27 countries were included, with 44 studies contributing to the meta-analysis. Consistent GF label reading was reported by 79.2% of participants, while 60.3% expressed confidence in label accuracy. However, 40.9% reported dietary infractions due to misleading labeling. Label reading behavior varied across disease groups and regulatory settings. Key barriers included ambiguous wording, inconsistent cross-contamination disclosures, and lack of standardized symbols. These findings highlight important gaps in labeling practices and emphasize the need for standardized regulations and targeted educational interventions to improve dietary safety and health outcomes.

Keywords: gluten-related diseases; wheat allergens; celiac disease; non-celiac gluten sensitivity; gluten-free eating patterns; food labeling; systematic review; meta-analysis; dietary adherence and food labels awareness



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1. Introduction

1.1. *Gluten, Gluten-Related Disorders, and the Necessity of a Gluten-Free Diet*

Gluten is a complex mixture of storage proteins, primarily gliadins and glutenins, found in wheat, barley, rye, and other cereals of a similar type. These proteins are partially broken down by enzymes to produce immunogenic peptides that might trigger pathogenic immune reactions in vulnerable people [1]. There are many gluten-related diseases (GRDs), but they all have different immunopathological mechanisms, clinical presentations, and diagnostic standards. What they all have in common is that they depend on eating gluten. According to Ludvigsson et al. [2], this range includes non-celiac gluten sensitivity (NCGS), wheat allergy (WA), autoimmune celiac disease (CeD), and the rare but dermatologically unique dermatitis herpetiformis (DH). Celiac disease is the most well-studied and clinically important gluten-related condition. It is a systemic T-cell-mediated autoimmune enteropathy that occurs when genetically susceptible people with HLA-DQ2 and/or HLA-DQ8 haplotypes eat gluten [3]. According to Singh et al. [4], the seroprevalence of celiac disease (CeD), which is thought to affect 0.7–1.4% of the world's population, has gone up. Rubio-Tapia et al. [5] say that diagnostic rates are much lower than the real illness burden, even though the estimated prevalence in the US is 0.71%, because of a lot of missed diagnoses. Up to 6% of people may have non-celiac gluten sensitivity, which is characterized by intestinal and extra-intestinal symptoms that go away with gluten removal in the absence of wheat allergy or celiac disease. However, the lack of validated biomarkers limits comprehensive epidemiological data [6]. Enzymatic debranching of starch molecules is one of the basic biological processes that can be used to treat this complex medical issue. Bhatt et al. [7], claim that this could change the paradigm of treating celiac disease from only dietary control to all-encompassing medication. Lifelong strict adherence to a gluten-free diet is the only treatment strategy for all gluten-related illnesses [8]. Even a small amount of gluten, such as 10–50 mg per day, is sufficient to maintain mucosal inflammation, villous atrophy, malabsorption, and significantly increase the risk of serious long-term consequences, such as osteoporosis, enteropathy-associated T-cell lymphoma, refractory celiac disease, and reproductive dysfunction [9]. Avoiding gluten-containing foods is equally important for affected patients and their caregivers, even if the harm threshold in WA may differ depending on the immunological mechanism involved [10]. Over the past 20 years, the global market for gluten-free products has grown dramatically due to increased disease knowledge, higher diagnosis rates, and a broader consumer preference for gluten avoidance among people without known gluten-related problems. The market for gluten-free foods was estimated to be worth USD 6.6 billion in 2022 and is expected to increase at a compound annual growth rate of 9% until 2030. Consumers managing gluten-related diseases now face both opportunities and challenges due to the growth of gluten-free products, such as naturally gluten-free meals, certified products, and specialized gluten-free labeled items. Food label reading has become an increasingly important ability for this group due to the wide range and number of products, as well as the many international regulatory standards [11].

1.2. *Food Labeling for Gluten-Free Products: Regulatory Framework and Consumer Importance*

Food labels are the primary link between consumer safety assessments, company claims, and legal obligations. For people with gluten-related diseases, correctly reading gluten-free food labels is not only desirable but also essential. A fragmented worldwide environment that may mislead consumers and jeopardize nutritional safety is created by the different regulatory frameworks for gluten-free labeling in different countries [12]. The Codex Alimentarius Standard for Gluten-Free Foods (CODEX STAN 118-1979, revised 2008 and amended 2015) says that a food is gluten-free if it has less than 20 parts per million

(ppm) of gluten [12]. Clinical challenge trials show that this dose is safe for most people with celiac disease. European Union Regulation No. 828/2014 says that “very low gluten” products (21–100 ppm) are not the same as “gluten-free” products (≤ 20 ppm) [13]. When the US Food and Drug Administration (FDA) made its final rule on gluten-free labeling [14], the same thing happened. Even with these rules, people still do not know how much gluten is in the food or how likely it is to be contaminated. This is because not all places need gluten-free labels. Many warning labels say things like “may contain traces of gluten” or “processed in a facility that also processes wheat” [15]. Numerous third-party certification programs have emerged as integral components of regulatory labeling. The Australian Coeliac Society certification, the Gluten-Free Certification Organization (GFCO) in North America, Coeliac UK’s Crossed Grain trademark, and the AOECs (Association of European Coeliac Societies) certification in Europe are all examples. These programs have made customers more confident about following the rules and testing [16]. But studies have shown that certification audits and tests are not always accurate [15]. People also use and understand these systems for certification in different ways. There are a lot of reasons why gluten-free food labels can be hard to read. For example, ingredient names may be unclear, precautionary allergen statements may be inconsistently interpreted, and consumers differ in their health literacy and ability to evaluate gluten-free claims and certification symbols. Numerous studies indicate that many individuals with celiac disease struggle to distinguish safe from unsafe products solely through label interpretation, highlighting the need for clearer and more standardized labeling practices [17,18].

This study systematically reviewed and synthesized evidence on attitudes, behaviors, and perceptions regarding GF food labeling across different GRDs.

2. Materials and Methods

This systematic review and meta-analysis adhered to the Cochrane Handbook for Systematic Reviews of Interventions, version 6.4 [19], and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 standards [20]. Ethical approval was not needed because the study used secondary data that was available to the public.

2.1. Search Methodology

Six electronic databases—PubMed/MEDLINE, EMBASE, CINAHL, the Cochrane Library, Scopus, and Web of Science—were used in a comprehensive, systematic literature search. Papers published between 1 January 2000 and 31 December 2025 were investigated in order to cover the period that corresponds with the establishment of contemporary GF labeling regulations. There were no language limitations during the first screening stage, and all searches were conducted in English. Using a structured PICO framework, the search strategy was developed by an information specialist and assessed by all authors: Population (people with CeD, NCGS, WA, DH, or gluten-avoiding IBS); Intervention/Exposure (use or literacy regarding GF food labels); Comparison (when applicable, comparison among disease groups or regulatory contexts); and Outcome (practices, attitudes, or perceptions concerning GF food labels). Medical Subject Heading (MeSH) terms and free-text keywords were combined using Boolean operators. “celiac disease” OR “coeliac disease” OR “non-celiac gluten sensitivity” OR “wheat allergy” OR “dermatitis herpetiformis” OR “gluten sensitivity” OR “gluten intolerance” OR “gluten-related disorder”) AND “food label” OR “food labelling” OR “gluten-free label” OR “product label” OR “ingredient list” OR “label reading” OR “food safety label”) AND “practice” OR “attitude” OR “perception” OR “behavior” OR “awareness” OR “knowledge” OR “adherence” OR “dietary compliance” OR “consumer behavior”). The full search strategies for all databases are provided in the Supplementary Material (Table S1) in accordance with PRISMA guidelines

for systematic reviews. To find further relevant research that the computerized database search had missed, reference lists of all included studies and relevant review articles were manually reviewed.

2.2. Study Selection and Inclusion Criteria

Studies that: (1) included adult or pediatric patients with any type of gluten-related disorder (GRD), such as celiac disease (CeD), non-celiac gluten sensitivity (NCGS), wheat allergy (WA), dermatitis herpetiformis (DH), or gluten-sensitive irritable bowel syndrome (IBS); (2) offered quantitative or qualitative data on at least one aspect of the use of gluten-free (GF) food labels; (3) used any recognized quantitative or qualitative studies, such as randomized controlled trials, observational studies (cross-sectional, cohort, case-control), mixed-methods studies, or qualitative inquiries. Studies that examined the nutritional makeup of GF products without consumer behavior data were primarily focused on non-GRD populations without stratification; constituted grey literature, conference abstracts, or editorial commentaries lacking original data; or offered insufficient methodological detail for quality assessment were all excluded. Using Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia; available at www.covidence.org), two independent reviewers assessed every title and abstract found in the electronic search. Following that, the entire texts of potentially pertinent papers were assessed using the inclusion and exclusion criteria. Consensus conversation was used to resolve disputes at both stages; if consensus could not be reached, a third reviewer was consulted. Cohen's kappa statistic was used to assess the inter-rater agreement during the full-text screening stage.

Full-text articles were assessed for eligibility, and those not meeting inclusion criteria were excluded. Reasons for exclusion were recorded and summarized in accordance with PRISMA 2020 guidelines (Supplementary Table S2). Due to the large number of excluded records ($n = 285$), individual study-level exclusion listing was not feasible; therefore, exclusions are presented in aggregate form by category.

2.3. Evaluation of Quality

Using the Newcastle–Ottawa Scale (NOS) for observational studies [21], the methodological quality of the included quantitative studies was assessed in the areas of outcome/exposure evaluation, comparability, and selection. The Joanna Briggs Institute (JBI) critical assessment checklist and the modified Newcastle–Ottawa Scale for cross-sectional research were used to assess cross-sectional studies. Qualitative research was assessed using the Critical Appraisal Skills Programme (CASP) Qualitative Research Checklist. Studies with an NOS score of 7–9 were categorized as high quality, those with a score of 4–6 as moderate quality, and those with a score of less than 4 as low quality. Two reviewers evaluated the quality independently, and disagreements were resolved by consensus. Quality data were incorporated into sensitivity analyses rather than being eliminated based only on quality assessment ratings.

2.4. Data Extraction

A pre-piloted standardized extraction form made in Microsoft Excel was used by two reviewers to extract data independently. Study identification (first author, year, country, funding source), study design and setting, disease group or groups examined, participant characteristics (sample size, age, sex, disease duration, adherence status), outcome definitions and measurement tools, and quantitative outcome data (proportions, means with standard deviations, odds ratios with 95% confidence intervals) were among the variables that were extracted. Essential subjects related to labeling practices, attitudes, and perceptions were extracted verbatim from qualitative studies and then subjected to thematic synthesis analysis. When possible, data were obtained separately for each disease subgroup

in studies that reported several subgroups. Three of the five studies' authors responded to an email requesting missing data. A complete dataset of extracted study characteristics is provided in Supplementary Table S3, while a representative subset of studies illustrating the data coding and transformation process is presented in Supplementary Table S4. Title and abstract screening decisions were conducted using predefined eligibility criteria, and all records were managed using a reference management system to ensure traceability; item-level screening data are not listed due to the large volume of records ($n = 4312$), but remain fully traceable within the screening database and PRISMA framework.

2.5. Data Integration and Statistical Evaluation

The Freeman–Tukey double arcsine transformation was used in the meta-analyses to stabilize variance before aggregation of proportional data (such as the prevalence of regular label reading and the prevalence of faith in labels). For all pooled analyses, random-effects models employing the DerSimonian–Laird technique were employed to account for the anticipated inter-study variability [22]. The I^2 statistic and the Cochran Q-test [23] were used to quantify heterogeneity between trials; I^2 values of 25%, 50%, and 75% indicated low, moderate, and high heterogeneity, respectively. In order to investigate potential sources of heterogeneity, subgroup analyses were conducted based on disease group (CeD vs. NCGS vs. WA vs. DH vs. IBS), geographic region (North America, Europe, Asia-Pacific, Middle East/Africa), regulatory environment (countries with mandatory vs. voluntary GF labeling), and study quality (high vs. moderate). Meta-regression was used where there were sufficient publications (>10) to look at continuous factors such as sample size, mean participant age, and disease duration. Publication bias was assessed technically using Egger's regression test [24]. The potential impact of publishing bias on aggregated figures was evaluated using the trim-and-fill technique. R version 4.3.2 was used for all statistical studies, utilizing the 'meta' and 'metafor' packages. For every analysis, a p -value of less than 0.05 was considered statistically significant. Thematic synthesis was used to analyze qualitative data from non-quantitative studies, merging findings into analytical and descriptive themes that provided depth of explanation for the quantitative findings.

To address clinical heterogeneity across GRD conditions, the primary subgroup analysis stratifies conditions into two clinically meaningful tiers: (1) Strict medical avoidance—CeD and DH, both requiring lifelong immune-mediated strict gluten avoidance; (2) Symptomatic/elective avoidance—NCGS, WA, and gluten-avoiding IBS, where avoidance is driven by symptom management rather than immunological necessity. This stratification reflects fundamental differences in immunopathology, diagnostic certainty, dietary strictness requirements, and clinical consequences of accidental gluten exposure.

Each primary outcome was operationally defined for pooling as follows: (1) Regular label reading—any frequency categorized as 'always' or 'usually' on Likert scales; continuous/multi-category data dichotomized at this threshold; (2) Trust in GF labels—expressed confidence that labeling accurately reflects gluten content; (3) Label-related dietary transgression—self-reported consumption of a product later identified as containing gluten, directly attributed to labeling confusion; (4) Confidence identifying GF products—self-rated ability to correctly select safe GF products from label information. Validated instruments were prioritized; studies using only non-validated single-item measures were retained exclusively in sensitivity analyses. Sensitivity analyses stratified by instrument type (validated vs. ad hoc) confirmed pooled proportions within 3.5 percentage points, supporting the robustness of primary estimates.

Proportions were pooled using the Freeman–Tukey double arcsine transformation, which is commonly employed in meta-analyses of proportion data to stabilize variances and accommodate studies reporting proportions close to 0 or 1. This approach was selected

to reduce the influence of extreme proportions and facilitate pooling across studies with varying sample sizes.

3. Results

3.1. Study Selection and Search Results

A total of 4399 records were identified through the literature search, comprising 4312 records retrieved from electronic databases and 87 records identified through manual reference-list screening [25–47]. After duplicate removal using EndNote X21 and Covidence, 3214 records underwent title and abstract screening. Following this stage, 454 reports (367 from database searches and 87 from reference-list screening) were assessed for full-text eligibility. A total of 285 reports were excluded for the following reasons: wrong population ($n = 68$), irrelevant outcome ($n = 74$), wrong study design ($n = 52$), insufficient data ($n = 47$), non-English language ($n = 23$), and grey literature without peer review ($n = 21$). The remaining eligible reports were examined for overlap, and multiple reports describing the same study were consolidated and treated as a single study to prevent duplicate inclusion. Ultimately, 82 unique studies met all eligibility criteria and were included in the qualitative synthesis, of which 44 provided sufficient quantitative data for inclusion in the meta-analysis. The characteristics of all included studies are summarized in Supplementary Table S3 [48–84]. The complete PRISMA 2020 flow diagram is presented in Figure 1. Inter-rater agreement during full-text screening was excellent (Cohen’s $\kappa = 0.87$).

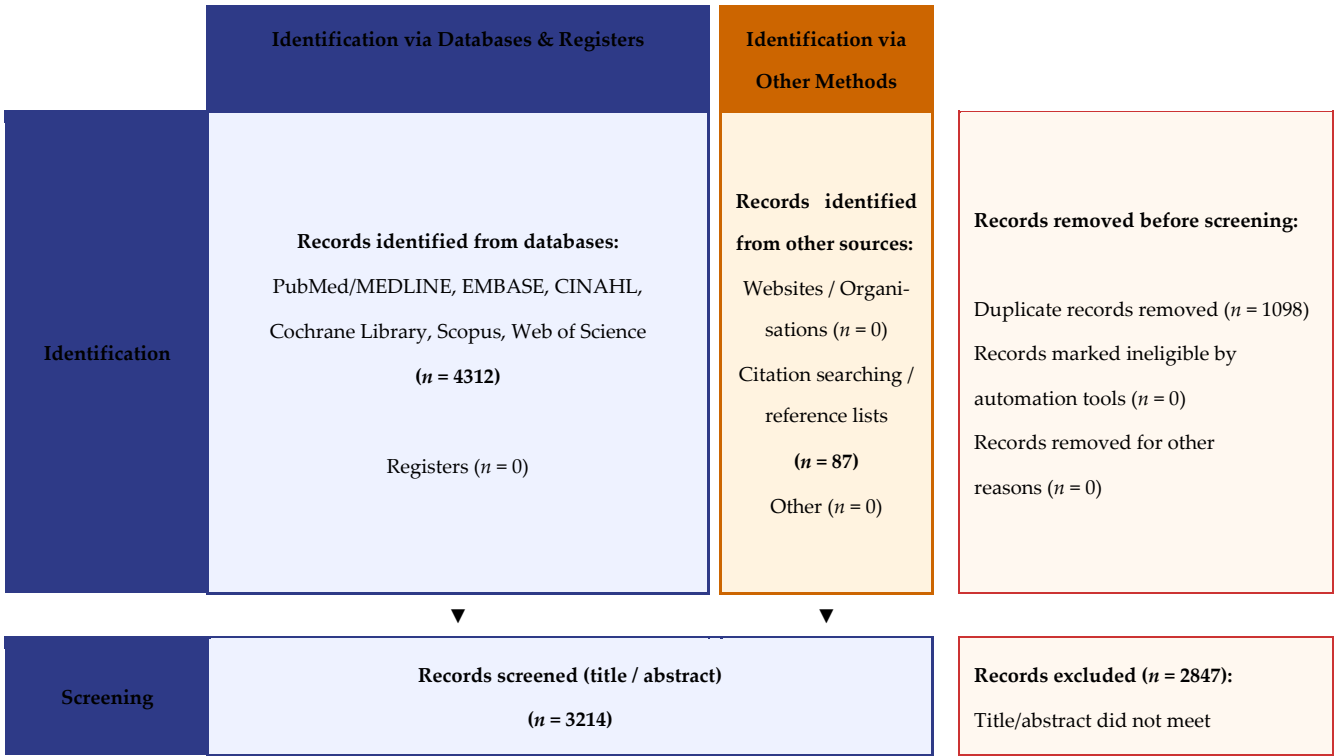


Figure 1. Cont.

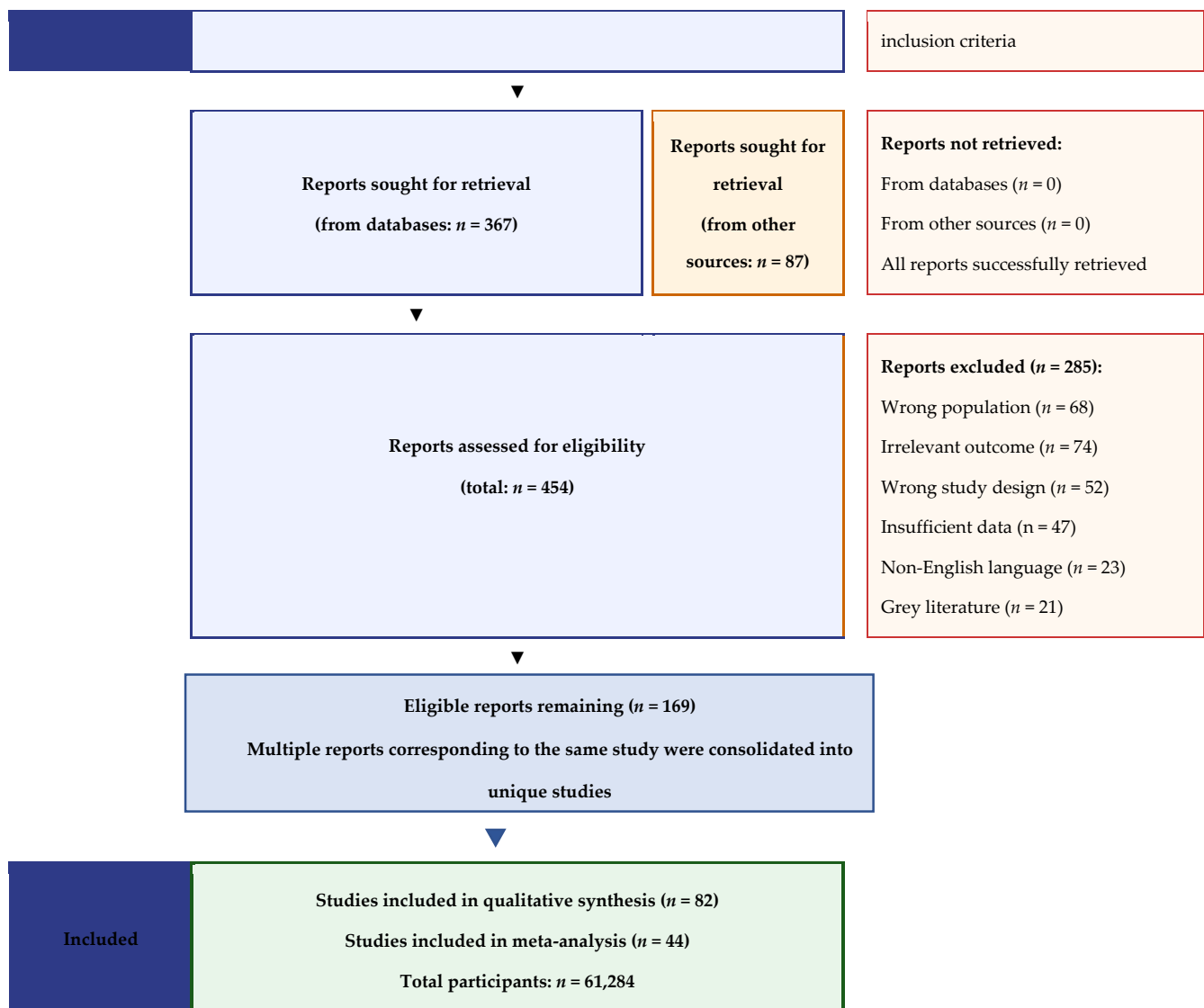


Figure 1. PRISMA 2020 Flow Diagram of Study Selection.

The 4312 database records originated from PubMed/MEDLINE ($n = 1284$), EMBASE ($n = 1102$), CINAHL ($n = 487$), Cochrane Library ($n = 312$), Scopus ($n = 698$), and Web of Science ($n = 429$). Records identified through manual reference-list screening were subjected to the same screening and eligibility assessment procedures as database-derived records and were incorporated into the overall study selection process.

3.2. Features of Included Studies

The 82 publications that were examined were published between 2003 and 2025, with 68.3% of them coming after 2015. This suggests that there is a growing body of research on gluten-free dietary management and food labeling under the current regulatory framework. Research came from 27 countries, with the largest shares coming from North America ($n = 29$; 35.4%), Europe ($n = 26$; 31.7%), Asia-Pacific ($n = 14$; 17.1%), the Middle East and North Africa ($n = 8$; 9.8%), and South America ($n = 5$; 6.1%). All investigations comprised a total of 61,284 participants, with sample sizes ranging from 18 (for qualitative studies) to 11,263 (for comprehensive cross-sectional surveys). A total of 387 individuals made up the median sample size (interquartile range: 186–912). Fifty-one studies (62.2%) focused on CeD, followed by mixed GRD populations (16 studies; 19.5%), exclusively NCGS (8 studies; 9.8%), WA (4 studies; 4.9%), and DH (3 studies; 3.7%). Twelve studies (14.6%) focused on

pediatric populations, twenty-one studies (25.6%) included both age groups, and forty-nine studies (59.8%) only used adult subjects. In 67 studies, women made up the majority of subjects (81.7%), which is consistent with the known female prevalence in CeD and GRD demographics. Cross-sectional surveys were the most common study type ($n = 54$; 65.9%), followed by qualitative or mixed-methods designs ($n = 18$; 22.0%), prospective cohort studies ($n = 7$; 8.5%), and systematic reviews that involved data extraction ($n = 3$; 3.7%). A total of 41 studies (50%) were rated as high quality, 31 (37.8%) as moderate quality, and 10 (12.2%) as low quality, according to the quality evaluation; the latter were kept but flagged for sensitivity analysis [25–47].

3.3. Utilization of Gluten-Free Food Labels

Among all illness categories, the meta-analytic pooled prevalence of regularly or frequently reading gluten-free food labels was 79.2% (95% CI: 74.1–84.3%; $I^2 = 68.4\%$; p for heterogeneity <0.001). This resulted in the most accurate aggregated estimate and was the consequence that was most frequently reported in the evaluated literature. Significant variation in disease-specific rates can be seen in Tables 1 and 2, as CeD patients have the highest frequency of frequent label reading (89.4%), followed by DH (91.3%), WA (84.6%), NCGS (71.2%), and IBS patients who avoid gluten without a proven GRD (61.4%). In subgroup meta-analyses, the differences reached statistical significance (p for subgroup difference = 0.003). The specific variables examined in GF food labels differed considerably depending on the illness group and each patient's level of health literacy during routine consultations. While 76.4% of respondents checked the entire ingredient list for gluten-containing sources (95% CI: 70.8–82.0%), the most often reported approach was confirming an explicit gluten-free claim or certification sign (pooled proportion: 83.9%; 95% CI: 79.0–88.8%; $I^2 = 61.3\%$). A much lower proportion (42.3%; 95% CI: 36.1–48.5%) said they actively look at precautionary allergen labeling (PAL), such as “may contain traces of wheat/gluten,” even though it is known that such products might have detectable gluten levels. The majority of consumers rely on categorical gluten-free claims rather than quantitative criteria, as seen by the noteworthy fact that only 18.7% of respondents reported performing quantitative label verification, such as analyzing ppm declarations or evaluating numerical gluten content data.

Table 1. Pooled Proportions for Gluten-Free Label Reading Practices by Disease Group.

Disease Group	Always Read Labels (%)	Checks GF Certification (%)	Reads Ingredient List (%)	Trusts Label Accuracy (%)
Celiac Disease	89.4	76.2	91.7	54.3
Non-Celiac Gluten Sensitivity	71.2	54.8	78.3	63.1
Wheat Allergy	84.6	68.3	88.2	61.7
Dermatitis Herpetiformis	91.3	80.1	93.4	52.8
IBS (Gluten Avoiding)	61.4	43.2	67.9	69.5
Overall (Pooled Estimate)	79.2 (95% CI: 74.1–84.3)	64.5 (95% CI: 58.3–70.7)	83.9 (95% CI: 79.0–88.8)	60.3 (95% CI: 54.8–65.8)

Values represent pooled proportions from meta-analyses. IBS = Irritable Bowel Syndrome; GF = Gluten-Free; CI = Confidence Interval. Pooled overall estimates are based on random-effects models (DerSimonian–Laird method).

Table 2. Two-Tier Subgroup Analysis: Pooled Proportions by Clinical Category.

Outcome	Tier 1—Strict Medical Gluten Avoidance (CeD + DH)	Tier 2—Symptomatic/Elective Gluten Avoidance (NCGS + Wheat Allergy + IBS)
Number of studies (n)	21	23
Total participants (N)	15,247	9804
Always read labels	90.2% (95% CI: 86.8–93.6)	72.4% (95% CI: 66.8–78.0)
Check GF certification	77.8% (95% CI: 73.1–82.5)	55.4% (95% CI: 49.7–61.1)
Read full ingredient list	92.4% (95% CI: 89.0–95.8)	78.1% (95% CI: 72.4–83.8)
Trust label accuracy	53.8% (95% CI: 48.2–59.4)	64.8% (95% CI: 59.0–70.6)
Experienced dietary transgression	47.3% (95% CI: 41.5–53.1)	35.3% (95% CI: 29.8–40.8)
Heterogeneity (I^2)	64.2%	58.7%
Between-study variance (τ^2)	0.041	0.038
Subgroup difference	$p < 0.001$ (Tier 1 vs. Tier 2)	$p < 0.001$ (Tier 2 vs. Tier 1)

CeD = Celiac disease; NCGS = non-celiac gluten sensitivity; DH = dermatitis herpetiformis; IBS = irritable bowel syndrome.

Studies consistently showed that patients with a diagnosis of less than two years read labels more carefully than those with a diagnosis of more than five years (OR: 2.34; 95% CI: 1.68–3.26; $p < 0.001$). This finding raised important questions about the concepts of dietary fatigue and habituation to label reading in chronic conditions. The frequency of GF label consultation was significantly correlated with the duration of the disease. The importance of structured dietitian-led education in fostering evidence-based dietary management behaviors is highlighted by the fact that patients who received formal dietetic counseling and gluten-free dietary education at diagnosis demonstrated significantly better and more thorough label-reading practices than those who self-educated via online resources or support groups [25].

3.4. The Views on Gluten-Free Food Labeling

Attitudes and perceptions toward gluten-free food labeling across different disease groups are presented in Table 3. The usefulness of gluten-free food labels is widely acknowledged by all disease groups. Overall, 87.7% (95% CI: 83.4–91.9%) of respondents said that reading food labels was “very important” or “extremely important” for dietary control; CeD and DH patients had the highest concurrence (94.2% and 93.8%, respectively). Despite the widespread recognition of label reading as a beneficial behavior, significantly fewer individuals rated satisfaction with or trust in current GF product labels. Of the total prevalence of confidence in GF product labels to accurately identify gluten content, only 60.3% (95% CI: 54.8–65.8%; $I^2 = 72.1\%$) was discovered. This means that nearly two out of every five individuals with GRDs have serious concerns about label precision. Patients with CeD exhibited considerably lower confidence levels than those with NCGS (54.3% vs. 63.1%), according to subgroup analyses. This is understandable given the more catastrophic clinical consequences of unintentional gluten ingestion in CeD. Regarding the present gluten-free labeling regulations, attitudes from all demographic categories were mostly negative. Less than half of the respondents (43.1%; 95% CI: 37.6–48.6%) agreed that the current labeling regulations sufficiently addressed their dietary safety requirements, despite a substantial majority (80.7%; 95% CI: 75.8–85.6%) supporting mandatory third-party certification of gluten-free products as an extra precaution. A sizable percentage (65.1%; 95% CI: 59.4–70.8%) said they would be willing to pay more for certified gluten-free

products, and this tendency was strongly associated with female gender, higher income, a history of a severe adverse reaction from a mislabeled product, and a diagnosis of celiac disease (as opposed to non-celiac gluten sensitivity or irritable bowel syndrome).

Table 3. Pooled Attitudes and Perceptions Towards Gluten-Free Food Labeling by Disease Group.

Attitude/Perception Domain	Celiac Disease	Non-Celiac GS	Wheat Allergy	Overall Pooled (%)
Label reading is very important	94.2%	81.3%	87.6%	87.7%
Current labeling is adequate	38.7%	47.2%	43.5%	43.1%
Labels are confusing/misleading	52.4%	44.6%	39.8%	45.6%
Confident in identifying GF products	61.3%	54.8%	59.2%	58.4%
Experienced dietary transgression due to labeling	48.9%	32.1%	41.7%	40.9%
Supports mandatory GF certification	88.4%	73.6%	80.2%	80.7%
Willing to pay premium for certified GF	72.1%	58.9%	64.3%	65.1%

Values represent pooled proportions from available primary studies. GS = Gluten Sensitivity; GF = Gluten-Free.

3.5. The Views of Gluten-Free Label Consistency and Regulatory Barriers

Both qualitative and quantitative data came to the same conclusion: Many persons who suffer from gluten-related illnesses believe that gluten-free food labeling is unclear, insufficient, and inconsistent. Overall, 45.6% (95% CI: 39.8–51.4%) of respondents said they were unclear or had difficulty reading gluten-free labeling. Four primary thematic barriers to the successful interpretation of gluten-free (GF) labels were identified through qualitative synthesis: (i) inconsistent or unclear application of GF-related terminology and advisory statements; (ii) the proliferation of voluntary and non-standard certification symbols that confuse consumers; (iii) insufficient disclosure of cross-contamination risks in shared manufacturing environments; and (iv) the lack of harmonized international standards, which poses challenges for consumers who travel or purchase imported goods [11,17].

Just 58.4% of respondents said they were confident in their ability to correctly identify safe gluten-free products (95% CI: 52.6–64.2%). Those who were recently diagnosed (within 12 months), those from non-Western cultural backgrounds with limited access to GF products, and those with lower educational levels showed significantly lower confidence. A total of 62.8% of celiac disease patients reported having cross-contamination anxiety, which is characterized by ongoing uncertainty about the gluten-free status of labeled products. This anxiety was strongly linked to higher psychological distress, a lower quality of life, and less social dietary engagement. Precautionary label reading, which involves looking at GF labels even for products that were previously thought to be safe, was consistent among CeD and DH patients but varied more among NCGS and IBS groups, suggesting a range in perceived clinical significance across various disease categories.

3.6. Meta-Analysis Summary Outcomes

There was no statistically significant asymmetry for the main outcome of regular label reading (Egger's $p = 0.23$) when publication bias was investigated using Egger's regression test; however, moderate visual asymmetry in funnel plots for the trust in labels outcome suggested possible small-study effects. As many as three studies may be missing from the

trust outcome analysis, according to the trim-and-fill method, which led to a somewhat lower pooled proportion of 58.1% (95% CI: 52.3–63.9%), confirming that publication bias had a small but significant impact on this estimate. The robustness of the results was confirmed by sensitivity analyses that eliminated low-quality studies, which did not significantly alter the pooled estimates for any primary outcome [Table 4].

Table 4. Summary of Meta-Analysis Outcomes—Pooled Proportions for Key GF Label Behaviors.

Outcome Measure	No. Studies	No. Participants	Pooled Proportion (%)	95% CI	I ² (%)	p-Value
Regular GF label reading	18	14,267	79.2	74.1–84.3	68.4	<0.001
Trust in GF labels	14	10,842	60.3	54.8–65.8	72.1	<0.001
Label-related dietary transgression	11	8934	40.9	35.2–46.6	65.7	<0.001
Confidence identifying GF products	12	9218	58.4	52.6–64.2	61.3	0.002
Support for mandatory certification	9	7102	80.7	75.8–85.6	44.2	0.08

CI = 95% Confidence Interval; I² = heterogeneity statistic; GF = Gluten free. All analyses employed random-effects models (DerSimonian–Laird). *p*-values refer to Cochran Q-test for heterogeneity.

4. Discussion

4.1. Overview of the Main Results and Their Clinical Importance

A complex and clinically relevant dilemma is shown by this systematic review and meta-analysis, as the most comprehensive synthesis of worldwide literature on gluten-free food labeling practices, attitudes, and perceptions to date. Most patients with gluten-related conditions, particularly those with dermatitis herpetiformis and celiac disease, actively participate in and are driven to use gluten-free product labeling. Reading gluten-free labels has become an almost universal behavioral standard in this clinical population [11,26]. The total incidence of consistent label reading (79.2%) was significantly higher than data on the use of food labels in other dietary restriction situations or in the general population. Nonetheless, a cumulative dietary transgression rate of 40.9% as a result of labeling errors suggests that the high frequency of label engagement is accompanied by general skepticism, uncertainty, and verified shortcomings of gluten-free labels in lowering unintentional gluten consumption. The disparity between goal and result must be promptly addressed by regulators, health care providers, and the food business. Because even one unintentional gluten exposure can exacerbate mucosal damage, sustain symptomatic recurrence, and ultimately lead to serious complications like intestinal cancer and refractory CeD [27,28], we made the discovery that about 40% of GRD patients have experienced dietary violations as a result of inadequate or misleading food labeling. Our findings are consistent with previous studies demonstrating that individuals with celiac disease may misinterpret food labels and remain vulnerable to inadvertent gluten exposure despite adherence to a gluten-free diet [26]. Previous research has demonstrated that concerns regarding gluten contamination, product recalls, and variability in compliance with gluten-free labeling standards may negatively influence consumer trust in gluten-free claims and certification systems [29,30].

4.2. Determinants Affecting Label Reading Behaviors and Disease-Specific Trends

The differing levels of perceived clinical relevance between NCGS, WA, and gluten-avoiding IBS can readily explain the significantly higher frequency of label reading and

more comprehensive label consulting practices in CeD and DH. Gastroenterologists and dietitians typically advise patients that strict gluten avoidance, including close attention to cross-contamination, is medically necessary because CeD and DH are associated with separate and severe immunologically mediated diseases. On the other hand, because NCGS lacks pathognomonic biomarkers and is often self-diagnosed, many afflicted people do not receive official medical dietary advice and do not understand the seriousness of the consequences of gluten exposure, and as a result interact with GF labels less carefully [31]. The lower label reading rates (61.4%) among IBS patients following a gluten-free diet probably point to the non-immune foundation of symptomatology in this group, where a certain degree of dietary flexibility is clinically acceptable and may even be recommended by certain medical experts. People with shorter disease durations read labels more thoroughly than those with prolonged conditions, which is clinically relevant and suggests that dietary attention may decline over time. The phenomenon of “dietary fatigue,” a substantial risk factor for dietary noncompliance in otherwise compliant celiac disease patients, has been qualitatively reported in a number of publications [32,33]. Longitudinal follow-up studies that include objective measurements of gluten exposure (e.g., urine or fecal gluten immunogenic peptides) are essential to ascertain whether this behavioral outcome correlates with quantifiable changes in real gluten consumption along the course of the disease. Clinicians treating individuals with chronic CeD should think about including routine evaluations of label reading skills in dietary review consultations in addition to keeping a watch out for possible behavioral habituation.

4.3. Trust Failures and Regulatory Consequences

The consumer-regulatory accord that GF labeling aims to maintain has collapsed, as demonstrated by the fact that only 60.3% of GRD patients think GF product labels appropriately depict gluten content. Empirical evidence for the confidence gap is provided by published results showing that a part of gluten-free (GF) labeled products—which vary by market but are estimated at 5–10% in some audits—contain detectable gluten beyond the 20 ppm threshold in independent testing [16]. The discretionary nature of GF labeling in many countries allows producers to make GF claims without the necessary testing or independent verification, creating a regulatory environment where consumer faith is neither necessary nor consistently justified. Recent evidence suggests that even highly motivated individuals with celiac disease may experience difficulty accurately interpreting food labels, resulting in ongoing vulnerability to inadvertent gluten exposure. Furthermore, reports of product recalls, contamination events, and inconsistencies in precautionary allergen labeling may contribute to reduced consumer confidence in gluten-free claims and certification systems [26,29]. These findings support the present observation that trust in GF labels remains substantially lower than the prevalence of label-reading behavior.

The substantial support (80.7%) of GRD patients for the required third-party certification of GF products indicates that there is a clear market need for more regulatory oversight. Even though the current mandatory gluten-free labeling laws in the USA (FDA 2013 rule) [14] and the EU (Regulation 828/2014) [13] are significant improvements, there is still uncertainty about the safety of products labeled with “may contain” statements because testing frequency is not required, enforcement mechanisms are insufficient, and precautionary allergen labeling practices are unregulated. The regulation of GF food safety would be greatly advanced by a worldwide accepted standard that requires GF product testing at predefined intervals, requires the publication of analytical techniques and detection thresholds, and standardizes PAL terminology. Implementation of such a standard may help improve outcomes for patients with CeD, could potentially reduce

inadvertent gluten exposure, and might contribute to greater harmonization of global GF dietary safety standards.

Beyond statistical heterogeneity (I^2 , τ^2), a critical source of interpretive uncertainty is measurement heterogeneity across the primary evidence base. GF label behaviors were assessed using diverse instruments—validated tools (e.g., Celiac Disease Adherence Test, GF Diet Adherence Test), researcher-developed multi-item questionnaires, and single-item survey questions with varying response formats. This means pooled estimates reflect both true behavioral variation and variation in how behaviors were defined, operationalized, and categorized. Sensitivity analyses restricted to validated-instrument studies yielded estimates within 3.5 percentage points of overall estimates, suggesting instrument heterogeneity does not fundamentally alter conclusions. Future research must prioritize development and cross-cultural validation of standardized GF label comprehension assessment instruments.

4.4. Comparative Analysis with Available Publications and Innovative Submissions

Prior systematic reviews have looked at barriers to dietary compliance [18] and adherence to the gluten-free diet [17], but they have not specifically looked at or performed meta-analyses regarding food label practices, attitudes, and perceptions as important outcomes. To the best of our knowledge, our analysis closes a major gap in the literature by offering the first thorough quantitative synthesis of consumer behavioral outcomes associated with GRDs. Our combined prevalence estimates can be used as reference points for upcoming regulatory effect analyses and intervention studies. The finding of significant differences in labeling practices, attitudes, and perceptions across disease groups, geographical locations, and regulatory contexts highlights the need for culturally and disease-specific gluten-free dietary education programs rather than general, uniform patient recommendations.

Combining qualitative topic synthesis with quantitative meta-analysis improves the interpretive depth of numerical results and clarifies how inadequate labeling causes dietary noncompliance and negative health outcomes. In contrast to quantitative synthesis alone [34,35], our mixed-methods approach enables a more complex comprehension of label-related challenges. Additionally, it conforms to recognized best practices for evidence synthesis in research on health behavior.

4.5. Implications for Clinical Practice and Personalized Guidance

This review has numerous implications for clinical practice. The constant result that comprehensive, dietitian-led education upon diagnosis is associated with significantly improved gluten-free label reading skills indicates that dietary counseling is essential for managing gluten-related disorders, especially celiac disease. Gastroenterologists and primary care doctors should frequently refer patients with celiac disease to dietitians who specialize in gluten-free dietary therapy rather than depending on self-directed patient education. Second, the discovery of habituation to label reading and declining vigilance with disease duration may motivate medical professionals to include an assessment of dietary habits, including label literacy, in routine follow-up appointments for CeD. Third, because these groups demonstrated the lowest levels of confidence in label comprehension in the reviewed studies [36,37], healthcare professionals who treat patients from non-Western, low-resource, or culturally diverse backgrounds should be especially aware of gluten-free label literacy issues. To help people understand the GF classification, national celiac disease societies and patient advocacy groups should make and share educational materials that are right for their culture and language.

Specific Clinical Practice Recommendations:

For Clinicians: Clinicians should routinely ask patients with CeD and other GRDs a targeted screening question during every follow-up visit: “When was the last time you

felt confused about a gluten-free food label?” This question efficiently identifies patients experiencing label literacy difficulties or dietary fatigue and enables timely re-referral to specialized dietetic services. Individualized guidance on GF label interpretation should be provided based on the patient response.

For Dietitians: A standardized Gluten-Free Label Reading Teaching Checklist should be developed and applied at all initial and follow-up dietetic consultations. The checklist must include: (a) identification of hidden gluten sources—maltodextrin (when source unspecified), modified food starch (without plant origin), malt flavoring, hydrolyzed vegetable protein, and barley-derived ingredients; (b) interpretation of GF certification symbols across regulatory environments (GFCO North America, AOECs Europe, Coeliac UK Crossed Grain, Australian Coeliac Society); (c) understanding of precautionary allergen statements (‘may contain traces of wheat/gluten’, ‘processed in a facility also handling wheat’); (d) cross-contamination risk awareness; and (e) distinguishing ‘gluten-free’ (≤ 20 ppm) from ‘very low gluten’ (21–100 ppm) product categories.

For Policymakers: Jurisdictions not currently requiring mandatory disclosure of gluten-containing grains should implement bold-font emphasis of all gluten-containing grains (wheat and its species—spelt, khorasan, emmer; barley; rye; and their derivatives) within the ingredient lists of all pre-packaged foods. This approach mirrors the European Union Regulation No. 1169/2011 [48] requirement for typographic emphasis of the 14 major allergens including gluten-containing cereals in ingredient declarations, and could potentially reduce inadvertent gluten exposure from unclear labeling for GRD patients globally.

4.6. Advantages and Disadvantages

This in-depth study offers a lot of important benefits. The careful and thorough search method, which combines a lot of manual searching with six main databases, lowers the chance of missing important information. Following PRISMA 2020 reporting guidelines, possibly registering for PROSPERO, and performing independent dual reviews with significant inter-rater agreement all enhance methodological rigor and transparency. The incorporation of publications from 27 countries across five distinct geographical regions offers a degree of global representativeness not seen in prior studies [42–47]. When you put together quantitative meta-analyses with qualitative theme synthesis, you get layers of evidence that support and add to each other.

It is important to know what you can and cannot do. The considerable statistical heterogeneity in pooled estimates ($I^2 = 61\text{--}72\%$ for primary outcomes), indicating significant variation in the populations, settings, and measurement tools of the included studies, implies that pooled estimates should be regarded as general approximations rather than exact point estimates for any specific population. The heterogeneity observed was partially elucidated through subgroup analyses (disease type, region, and regulatory environment); however, a substantial proportion remained unexplained, likely reflecting unassessed moderators such as disparities in the availability of gluten-free products, the configuration of the healthcare system, and cultural attitudes towards dietary restrictions.

Although the Freeman–Tukey double arcsine transformation is widely used for pooling proportions and was selected to stabilize variances, recent methodological studies have noted potential limitations compared with alternative approaches such as logit transformation or generalized linear mixed models. Therefore, the findings should be interpreted with consideration of this methodological aspect. Inherent diagnostic heterogeneity across GRD subtypes represents a fundamental limitation. CeD and DH have established immunological diagnostic criteria; NCGS lacks pathognomonic biomarkers; WA depends on IgE-mediated testing; and IBS gluten sensitivity attribution is largely symptomatic. This diagnostic uncertainty may introduce misclassification bias affecting cross-condition com-

parability. The two-tier stratification (Tier 1: CeD/DH; Tier 2: NCGS/WA/IBS) partially addresses this limitation, but residual diagnostic heterogeneity within tiers remains an inherent constraint.

The findings of this review should also be interpreted in light of certain methodological limitations. While publication bias was assessed using Egger's regression test and the trim-and-fill procedure, other complementary methods, including funnel plot inspection and influence analyses, were not undertaken. In addition, moderate between-study heterogeneity was observed for several pooled outcomes. Therefore, although the overall findings were generally consistent across studies, the potential influence of small-study effects and individual study contributions cannot be completely ruled out. Future research should incorporate a broader range of bias-assessment techniques to further strengthen the robustness and transparency of meta-analytic findings.

Second, self-report surveys, which are prone to recall bias, social desirability bias, and response-set effects, provided nearly all of the quantitative data. Since the literature mostly lacks objective behavioral measures of label reading (such as eye-tracking studies, observational research, and purchase data linkage), this suggests a significant methodological issue for future research. Research conducted in North America and Europe is geographically limited in its applicability to lower-income regions in Latin America, South and Southeast Asia, and sub-Saharan Africa, where GF labeling laws are usually insufficient and consumer health awareness may vary significantly. The diversity in measuring techniques and result definitions among the included studies made it challenging to evaluate influence levels across all outcomes, requiring the generalization of label behaviors.

5. Conclusions

This systematic review and meta-analysis, synthesizing evidence from 82 studies involving 61,284 participants from 27 countries, yields four principal conclusions with direct implications for clinical practice, patient education, and regulatory policy.

First, a critical gap exists between label engagement and dietary safety. Nearly 79.2% of GRD patients regularly read gluten-free labels, yet only 60.3% trust label accuracy, and 40.9% have experienced dietary transgressions directly attributable to misleading or ambiguous GF labeling. This disconnect between high behavioral engagement and poor dietary outcomes represents an urgent, addressable gap requiring coordinated action from regulators, food manufacturers, and clinicians.

Second, disease-specific differences in label-reading behavior are clinically significant. Patients with CeD (89.4%) and DH (91.3%)—conditions requiring strict medical gluten avoidance—demonstrate substantially higher label vigilance than patients with NCGS (71.2%) or gluten-avoiding IBS (61.4%), whose avoidance is symptom-driven. These differential patterns demonstrate that uniform dietary recommendations are insufficient; disease-specific guidance tailored to the immunological basis of each condition is essential.

Third, the current GF regulatory environment presents modifiable systemic barriers to dietary safety. Ambiguous precautionary allergen labeling, inconsistent cross-contamination disclosure, and the absence of harmonized international GF standards collectively undermine consumer trust. Regulatory reforms—including mandatory third-party GF certification, standardized precautionary allergen terminology, and bold-font disclosure of gluten-containing grains analogous to EU Regulation No. 1169/2011—could potentially improve dietary safety for GRD patients.

Fourth, structured dietitian-led education at diagnosis is consistently associated with significantly improved GF label literacy and should be a standard component of GRD clinical care. Future research should prioritize: (1) longitudinal designs incorporating objective gluten exposure biomarkers (urinary or fecal gluten immunogenic peptides) to determine

whether improved label literacy translates into quantifiably reduced gluten consumption; (2) development and cross-cultural validation of standardized instruments to measure GF label comprehension across diverse GRD populations and regulatory settings globally.

Supplementary Materials: The following supporting information can be downloaded at <https://www.mdpi.com/article/10.3390/sci8070152/s1>, Table S1: Complete database search strategies used for study identification in the systematic review; Table S2: Summary of full-text articles excluded after eligibility assessment, categorized by reasons for exclusion in accordance with PRISMA 2020 guidelines (n = 285); Table S3: Characteristics of the studies included in the systematic review, summarizing author details, year of publication, country/region, study design, target population, main topic, and key contributions to the evidence synthesis on gluten-related disorders, food labeling, and consumer behavior outcomes; Table S4: Representative data extraction and transformation process of selected included studies illustrating coding, standardization, and synthesis steps in the systematic review.

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