https://doi.org/10.22516/25007440.1289

Original article

Comorbidities of Irritable Bowel Syndrome in Colombia: Analysis of Data from the Ministry of Health

Natalia Saade-Cleves,[1*] Diego Rosselli.[2]

OPEN ACCESS

Citation:
Saade-Cleves N, Rosselli D. Comorbidities of Irritable Bowel Syndrome in Colombia: Analysis of Data from the Ministry of Health. Revista. colomb. Gastroenterol. 2025;40(2):145-152. https://doi.org/10.22516/25007440.1289

[1] Physician and Surgeon. Pontificia Universidad Javeriana Bogotá, Colombia.
[2] Neurologist and Epidemiologist, currently Professor in the Department of Clinical Epidemiology and Biostatistics at Pontificia Universidad Javeriana and Hospital San Ignacio. Bogotá, Colombia.

***Correspondence:** Natalia Saade.
natalia_saade@javeriana.edu.co

Received: 02/10/2024
Accepted: 15/05/2025

Abstract

Irritable bowel syndrome (IBS) is the most common functional disorder of the gastrointestinal tract, characterized by altered bowel habits associated with chronic abdominal pain. In this context, a descriptive study was conducted using the Individual Health Service Provision Records (Registros Individuales de Prestación de Servicios de Salud – RIPS), the official healthcare services database from the Ministry of Health of Colombia. ICD-10 codes K580 (irritable bowel with diarrhea) and K589 (irritable bowel without diarrhea) were used to identify all registered patients between 2018 and 2022. Prevalence ratios of selected comorbidities described in the literature were calculated and compared to individuals without that diagnosis, stratified by age and sex. Our findings indicate a lower overall prevalence in Colombia (2.7%) compared to previously reported figures, with a female-to-male ratio of 2.2. Diagnoses such as fibromyalgia, depression, anxiety, polycystic ovary syndrome, migraine, schizophrenia, and post-traumatic stress disorder were found to be more prevalent in patients with IBS. Fibromyalgia had the highest prevalence ratio, with IBS patients being seven times more likely to receive this diagnosis, while schizophrenia had the lowest, with a 36% higher prevalence among IBS patients. The literature highlights shared pathophysiological pathways, including alterations in the gut microbiome, neurotransmitter metabolism, intestinal permeability, a pro-inflammatory gut environment, and neuronal sensitization. These findings underscore the increased risk of developing these comorbidities among individuals with IBS and highlight the need for further research in this area.

Keywords

Irritable bowel syndrome, comorbidity, fibromyalgia, mental disorders, gastrointestinal microbiome.

INTRODUCTION

Irritable bowel syndrome (IBS) is a functional gastrointestinal disorder characterized by altered bowel habits, often associated with chronic abdominal pain, diarrhea, constipation, or both, as well as abdominal bloating[1,2]. Diagnosis is based on the Rome IV criteria, which require recurrent abdominal pain at least one day per week for the past three months, associated with two or more of the following: changes in stool frequency or consistency. Symptoms must have been present for at least six months prior to diagnosis[2]. A literature review spanning articles from 1978 to 2013 reported a global prevalence of 10%–25%, with regional variations and a female-to-male ratio of 1.5–3:1, alongside lower diagnosis rates after age 50. The review also noted higher familial clustering of IBS (suggesting genetic and lifestyle components), no socioeconomic disparities, increased healthcare utilization among patients, and reduced quality of life due to disease chronicity, symptom exacerbations, and comorbidities such as fibromyalgia, depression, and anxiety[3]. Additionally, it highlighted inconsistencies in epidemiological data stemming from varying diagnostic criteria (e.g., Manning, Rome II, Rome III)[3].

Colombian data vary by diagnostic criteria. A 2009 cross-sectional study using self-administered questionnaires in Bucaramanga reported a prevalence of 19.9% under Rome III criteria, with 62.4% of cases occurring in women. Logistic regression analysis revealed an association between depressive symptoms and female sex[4]. A global study combining online surveys (24 countries) and in-person interviews (7 countries) reported a Colombian prevalence of 4.3% using Rome IV criteria in adults[5]. The same authors noted that over 40% of people worldwide experience functional gastrointestinal disorders at some point, though diagnoses decline when using Rome IV versus Rome III criteria[5].

Due to its high frequency, IBS is considered a public health priority[6]. Beyond gastrointestinal symptoms, IBS is associated with conditions such as fibromyalgia[7], depression, anxiety[8], polycystic ovary syndrome[9], migraine[10], schizophrenia[11], and post-traumatic stress disorder[12]. Its pathophysiology involves genetic factors, chronic stress exposure, visceral hypersensitivity, immune dysregulation, intestinal permeability, gut-brain axis disruption, and microbiota alterations[6].

Colombia is the only country in the region with universal health coverage for its 50 million inhabitants. Its healthcare system operates under a single-payer model with two dozen public and private insurers reimbursing providers. This relatively complex scheme relies on a structured information system based on Individual Service Provision Records (RIPS). For each patient encounter, providers must complete RIPS forms with basic patient identifiers and one or more diagnoses coded per ICD-10 (International Classification of Diseases, Tenth Revision) to receive reimbursement. Over 500 million RIPS are collected annually[13]. These records have been used in research to estimate, for example, rheumatoid arthritis prevalence[14], disability-adjusted life years for gastric cancer[15], and demographic characteristics of Sjögren's syndrome[16].

MATERIALS AND METHODS

Access to the RIPS database was obtained through Excel 2016 using pivot tables, which connect via personal login credentials provided by the Ministry of Health for research purposes to one of the investigators (DR). The search was limited to patients treated during the five-year period from 2018 to 2022. Data were filtered by "unique patients" to ensure individuals with multiple contacts during this period were counted only once. Analysis was stratified by sex and age, with three age groups: 0–14 years, 15–64 years, and ≥65 years. ICD-10 codes K580 (irritable bowel syndrome with diarrhea) and K589 (irritable bowel syndrome without diarrhea) were used to identify IBS cases.

To evaluate comorbidities, the following ICD-10 codes were employed: anxiety: F411 (generalized anxiety disorder); depression: F320-F329 (encompassing mild, moderate, and severe depression); severe depression: F322-F323 and F332-F333; polycystic ovary syndrome: E282; migraine: G430-G439; fibromyalgia: M797; schizophrenia: F200-F209; and post-traumatic stress disorder: F431. Comorbidities were selected based on clinical relevance and documented associations with IBS. While conditions like depression and anxiety are well-established in IBS patients, less-studied psychiatric disorders (schizophrenia and PTSD) were included to explore potential associations. Clinically observed conditions frequently comorbid with IBS—such as fibromyalgia, polycystic ovary syndrome, and migraine—were also prioritized for analysis. Although other comorbidities are documented in literature, this study focused on a selected diagnostic group.

Patients with IBS were then compared to the general population to determine prevalence ratios (PR) for each condition. General population prevalence used the total treated population (stratified by age and sex) during the study period as the denominator.

Ethical Considerations

As this study involved secondary analysis of a consolidated, anonymized public database, ethics committee approval was not required.

RESULTS

From 2018 to 2022, 53,032,244 individuals received healthcare services nationwide. Of these, 1,423,175 patients (981,454 women; 68.9%) were documented with either ICD-10 code for IBS (K580 or K589), yielding an estimated general population prevalence of 2.7% in Colombia during this period. The study population (ages 0–100 years) demonstrated age-specific patterns (**Figure 1**), with most cases occurring among young adults. Prevalence was relatively low in children under 15 (3.38 per 1,000), slightly higher in girls (3.66) than boys (3.12). Among adults aged 15–64, prevalence rose to 32.2 per 1,000 (women: 41.7; men: 21.3 per 1,000), and was highest in those over 65 (40.0 per 1,000; women: 50.9; men: 26.9 per 1,000).

Table 1 presents case counts and prevalence rates per 1,000 for eight comorbid conditions.

Table 2 presents the number of individuals diagnosed with each of the eight conditions of interest, along with the number of patients having coexisting IBS diagnoses and their respective prevalence rates. The prevalence ratio indicates how much higher the prevalence is compared to the general population without IBS.

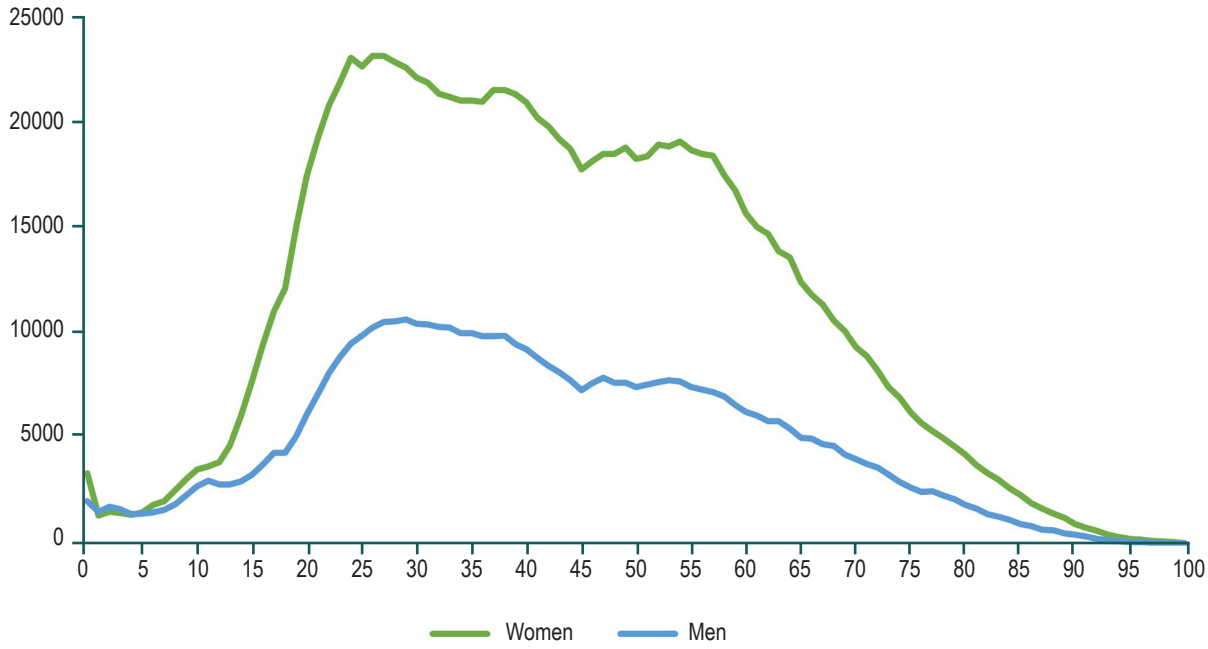

Figure 1. Age and sex distribution of 1,423,175 IBS-diagnosed individuals in Colombia (2018–2022). Image property of the authors.

Table 1. Sex-stratified diagnoses and prevalence (per 1,000) of comorbid conditions (2018–2022)

Condition	Women		Hombres	
	Cases	Prevalence	Cases	Prevalence
Anxiety	187,135	6.7	93,587	3.7
Depression	678,322	24.2	268,177	10.7
Severe depression	94,369	3.4	49,130	2.0
Polycystic ovary syndrome	429,497	15.4		
Migraine	1,639,853	58.6	444,270	17.7
Fibromyalgia	99,807	3.6	7573	0.3
Schizophrenia	96,707	3.5	120,634	4.8
PTSD	16,776	0.58	12,633	0.49

Table prepared by the authors.

Table 2. Total recorded cases for each diagnosis in Colombia (2018-2022), number of cases with coexisting irritable bowel syndrome (IBS) diagnosis, prevalence per 1000 IBS patients, and prevalence ratio (PR) compared to individuals without IBS

Comorbidity	Cases	With IBS	Prevalence	PR
Anxiety	280,722	27,792	19.5	3.98
Depression	946,499	73,182	51.4	3.04
Major Depression	143,499	10,176	7.2	2.77
Polycystic ovary syndrome	426,502	32,190	32.8	2.23
Migraine	2,084,123	170,757	120.0	3.24
Fibromyalgia	107,380	18,067	12.7	7.34
Schizophrenia	217,341	7772	5.5	1.34
PTSD	29,409	1738	1.2	2.28

Table prepared by the authors.

DISCUSSION

The global prevalence of IBS has been estimated at 11.2%, with significant regional variations. According to a systematic review and meta-analysis, the lowest prevalence occurs in Southeast Asia (7%), while the highest is found in South America (21%)[17]—similar to the 10%–25% global prevalence range reported in the previously mentioned literature review[3]. In Colombia, prevalence based on Rome III criteria was approximately 19.9% in a university study using electronic questionnaires with a random sample of adults in Bucaramanga[4]. A 2017 cross-sectional study at Pontificia Universidad Javeriana in Bogotá reported a 24% prevalence using Rome III criteria[18], contrasting with the 4.3% prevalence found using Rome IV criteria in the global study cited earlier[5]. Our study identified a general population prevalence of 2.7% in Colombia (2018–2022), lower than literature reports, likely due to underdiagnosis and underreporting.

Two-thirds of diagnoses occurred in women (female-to-male ratio: 2.2:1), consistent with existing literature[3,8,17]. While prior studies note decreased prevalence after age 50[3,17], we observed persistently high prevalence among older adults.

All analyzed comorbidities were more frequent in IBS patients than in the general population—from schizophrenia (34% higher prevalence) to fibromyalgia (7-fold higher). These conditions share potential underlying pathophysiologies: dysbiosis, nervous system sensitization, and adrenal axis activation[1,6,9,10–12,19].

Anxiety diagnoses were four times more common in IBS patients, while depression (aggregated mild/moderate/severe or major depression alone) was approximately three times more prevalent. Literature reports that 40%–90% of IBS patients meet criteria for mental health disorders, particularly depression and anxiety[19]. This reflects the gut-brain axis relationship, where bidirectional communication occurs between the enteric and central nervous systems[19].

One of the key shared mechanisms is intestinal microbiota dysregulation. Dysbiosis compromises the intestinal barrier, increasing permeability while simultaneously heightening pain sensitivity and altering motility (hallmarks of IBS). Elevated proinflammatory cytokine production may also exert cerebral effects linked to depression and anxiety[19,20]. This dysbiosis mechanism similarly connects to polycystic ovary syndrome (PCOS), which demonstrates immunoinflammatory responses alongside visceral hypersensitivity and motility alterations[9]. Our study found PCOS prevalence 2.23 times higher in IBS patients than in unaffected women. Sex hormones (testosterone, estrogen, progesterone) can modify gut microbiome composition, while conversely, altered microbiota may influence hormonal regulation[9,21]. The inflammation secondary to intestinal permeability in IBS has been implicated in migraine[22] and fibromyalgia—conditions sharing microbial dysbiosis patterns like reduced *Bifidobacterium* and *Ruminococcaceae*, and increased *Clostridium scindens*, though with distinct *Eubacterium* and *Rikenellaceae* profiles[7,23,24].

Serotonin plays a pivotal role in these pathophysiological interactions. Approximately 90% of serotonin resides in the gastrointestinal tract, regulating peristalsis and intestinal secretion. Altered serotonin metabolism may drive visceral hypersensitivity and is linked to anxiety/depression disorders[20]. Variants of the *5-HT* gene (encoding G protein-coupled serotonin receptors) associate with IBS symptoms—e.g., the *5-HT3* receptor subtype correlates with proalgesic effects, particularly in IBS-D[25]. In migraine, serotonin transporter polymorphisms relate to migraine with aura. Even in schizophrenia, serotonin metabolism alterations may connect both conditions, though evidence remains limited[26]. A 2015 review found 19% IBS prevalence among schizophrenia patients[11], whereas a cohort study showed no statistically significant schizophrenia incidence difference in IBS patients (relative risk [RR]: 1.8; 95% confidence interval [CI]: 0.9–3.6)[27].

Central nervous system sensitization is evident in fibromyalgia, which demonstrated the strongest IBS association in our study (7-fold higher diagnosis rate versus general population). Shared mechanisms include peripheral sensitization with enhanced ascending pain pathway activation and impaired descending inhibition in both conditions[28]. Both disorders also exhibit sympathetic nervous system and hypothalamic-pituitary-adrenal axis hyperactivity, impacting intestinal motility[28,29]. Neuroimaging in IBS and fibromyalgia patients suggests sensitization stems from dysfunctional anterior cingulate cortex inhibition, increasing insular activity to stimuli[30].

This central sensitization also manifests in PTSD, where IBS patients showed doubled risk (prevalence ratio: 2.28) following stressful events. Kearney et al. reported higher IBS prevalence among veterans with PTSD versus the general population[31]. PTSD and IBS share gut-brain axis dysregulation and central sensitization—an amplified response to repeated stimuli occurring at cellular and psychological levels, primarily mediated by the limbic system[30]. In IBS patients, exaggerated stress responses may alter motility, permeability, and visceral sensitivity, promoting gastrointestinal inflammation, microbiota disruption, and elevated risk for inflammatory digestive disorders like IBS[19].

When central sensitization increases responsiveness to stimuli in central nervous system nociceptors—where minor stimuli may trigger severe pain perception[32]—this mechanism also potentially underlies the IBS-migraine relationship, mediated by genetic factors, mitochondrial dysfunction,

and microbiota alterations[25]. Our study found IBS patients had triple the migraine risk versus the general population. Todorov et al.'s systematic review/meta-analysis reported an odds ratio (OR) of 2.09[25], suggesting migraine may share previously discussed mechanisms involving dysbiosis, central sensitization, and serotonin receptor genetics.

The corticotropin-releasing system also emerges as a shared pathway. This system induces gastrointestinal proinflammatory states via CRF1 receptor (corticotropin-releasing factor with urocortin 1) activation in enteric neurons, accelerating colonic transit[33]. Within the hypothalamic-pituitary-adrenal axis, physical or psychosocial stress elevates catecholamines, disrupting gut microbiota and exacerbating anxiety symptoms[19,34]. Concurrently, increased intestinal permeability, dorsolateral prefrontal cortex dysfunction, elevated interleukin-2 (IL-2), and B-cell activation—mechanisms also implicated in fibromyalgia—have been documented[20,28,35,36].

ETHICAL CONSIDERATIONS

As a secondary analysis of anonymized public data, informed consent was waived per Article 11 of Colombia's Ministry of Health Resolution 8430 (1993), classifying this as no-risk research. Ethics committee approval was therefore unnecessary.

This study received no funding and involved no conflicts of interest or artificial intelligence use.

CONCLUSIONS

Our study revealed lower IBS prevalence than literature reports, potentially reflecting underdiagnosis, underreporting, or diagnostic criteria variations. Crucially, it highlights elevated risks of mental health disorders (depression, major depression, anxiety, PTSD, schizophrenia) and somatic conditions (migraine, polycystic ovary syndrome (PCOS), fibromyalgia) in IBS patients. Fibromyalgia showed the strongest association (7-fold higher prevalence versus general population), while schizophrenia demonstrated the weakest (34% increased diagnosis rate).

Underlying mechanisms emphasize gut microbiota's role—particularly through neurotransmitter metabolism (especially serotonin), intestinal permeability changes, and proinflammatory environments—across all associated conditions, warranting further research. Central/peripheral sensitization also features prominently in these shared pathophysiological pathways.

REFERENCES

1. Sebastián Domingo JJ. Síndrome del intestino irritable. Med Clin (Barc). 2022;158(2):76-81. https://doi.org/10.1016/j.medcli.2021.04.029
2. Mearin F, Ciriza C, Mínguez M, Rey E, Mascort JJ, Peña E, et al. Guía de práctica clínica: síndrome del intestino irritable con estreñimiento y estreñimiento funcional en adultos: concepto, diagnóstico y continuidad asistencial. Semergen. 2017;43(1):43-56. https://doi.org/10.1016/j.semerg.2016.06.009
3. Canavan C, West J, Card T. The epidemiology of irritable bowel syndrome. Clin Epidemiol. 2014;6:71-80. https://doi.org/10.2147/CLEP.S40245
4. Gómez DF, Morales JG, Aurelio LM, Mujica SC, Camacho PA, Rueda GE. Factores sociosanitarios y prevalencia del síndrome del intestino irritable según los criterios diagnósticos de Roma III en una población general de Colombia. Gastroenterol Hepatol. 2009;32(6):395-400. https://doi.org/10.1016/j.gastrohep.2009.01.177
5. Sperber AD, Bangdiwala SI, Drossman DA, Ghoshal UC, Simren M, Tack J, et al. Worldwide prevalence and burden of functional gastrointestinal disorders, results of Rome Foundation Global Study. Gastroenterology. 2021;160(1):99-114. https://doi.org/10.1053/j.gastro.2020.04.014
6. Bustos-Fernández LM. Síndrome de intestino irritable: la importancia de los antiespasmódicos. Rev Colomb Gastroenterol. 2020;35(3):338-344. https://doi.org/10.22516/25007440.523
7. Garofalo C, Cristiani CM, Ilari S, Passacatini LC, Malafoglia V, Viglietto G, et al. Fibromyalgia and irritable bowel syndrome interaction: a possible role for gut microbiota and gut-brain axis. Biomedicines. 2023;11(6):1701. https://doi.org/10.3390/biomedicines11061701
8. Mayer EA, Ryu HJ, Bhatt R. The neurobiology of irritable bowel syndrome. Mol Psychiatry. 2023;28(4):1451-1465. https://doi.org/10.1038/s41380-023-01972-w
9. Wei Z, Chen Z, Xiao W, Wu G. A systematic review and meta-analysis of the correlation between polycystic ovary syndrome and irritable bowel syndrome. Gynecol Endocrinol. 2023;39(1):2239933. https://doi.org/10.1080/09513590.2023.2239933
10. Wongtrakul W, Charoenngam N, Ungprasert P. Increased prevalence of irritable bowel syndrome in migraine patients: a systematic review and meta-analysis. Eur J Gastroenterol Hepatol. 2022;34(1):56-63. https://doi.org/10.1097/MEG.0000000000002065
11. Amir Garakani, Win T, Virk S, Gupta S, Kaplan DS, Masand PS. Comorbidity of irritable bowel syndrome in psychiatric patients: A review. Am J Ther. 2003;10(1):61-67. https://doi.org/10.1097/00045391-200301000-00014
12. Ng QX, Soh AYS, Loke W, Venkatanarayanan N, Lim DY, Yeo WS. Systematic review with meta-analysis: The association

between post-traumatic stress disorder and irritable bowel syndrome. J Gastroenterol Hepatol. 2019;34(1):68-73. https://doi.org/ 10.1111/jgh.14446
13. Rosselli D, Pantoja-Ruiz C. SISPRO: The administrative database of the Colombian healthcare system. Acta Neurol Colomb. 2022;38(4):187-190. https://doi.org/10.22379/24224022426
14. Fernández-Ávila DG, Rincón-Riaño DN, Bernal-Macías S, Gutiérrez JM, Rosselli D. Prevalencia de la artritis reumatoide en Colombia según información del Sistema Integral de Información de la Protección Social. Rev Colomb Reumatol. 2019;26(2):83-87. https://doi.org/10.1016/j.rcreu.2019.01.003
15. Triana Guzmán JJ, Aristizábal Mayor JD, Medina Rico M, Baquero Contreras L, Gil Tamayo S, Leonardi F, et al. Carga de enfermedad en años de vida ajustados por discapacidad del cáncer gástrico en Colombia. Rev Colomb Gastroenterol. 2017;32(4):326- 331. https://doi.org/10.22516/25007440.175
16. Fernández-Ávila DG, Rincón-Riaño DN, Bernal-Macías S, Gutiérrez Dávila JM, Rosselli D. Prevalence and demographic characteristics of Sjögren's syndrome in Colombia, based on information from the official Ministry of Health registry. Reumatol Clin (Engl Ed). 2020;16(4):286-289. https://doi.org/10.1016/j.reuma.2018.09.005
17. Lovell R, Ford A. Global prevalence of and risk factors for irritable bowel syndrome: a meta-analysis. Clin Gastroenterol Hepatol. 2012;10(7):712-721. https://doi.org/10.1016/j.cgh.2012.02.029
18. Cañón M, Ruiz AJ, Rondón M, Alvarado J. Prevalence of irritable bowel syndrome and health-related quality of life in adults aged 18 to 30 years in a Colombian university: an electronic survey. Ann Gastroenterol. 2017;30(1):67-75. https://doi.org/10.20524/aog.2016.0093
19. Vergara-Alvira MS, Ahumada-Ossa LM, Poveda- Espinosa E. Estrés, depresión, ansiedad y el hábito alimentario en personas con síndrome de intestino irritable. Rev Colomb Gastroenterol. 2022;37(4):369-382. https://doi.org/10.22516/25007440.899
20. Holtmann G, Ford AC, Talley NJ. Pathophysiology of irritable bowel syndrome. Lancet Gastroenterol Hepatol. 2016;1(2):133-146. https://doi.org/10.1016/S2468-1253(16)30023-1
21. He S, Li H, Yu Z, Zhang F, Liang S, Liu H, et al. The gut microbiome and sex Hormone-Related diseases. Front Microbiol. 2021;12:711137. https://doi.org/10.3389/fmicb.2021.711137
22. De Roos NM, Van Hemert S, Rovers JMP, Smits MG, Witteman BJM. The effects of a multispecies probiotic on migraine and markers of intestinal permeability-results of a randomized placebo-controlled study. Eur J Clin Nutr. 2017;71(12):1455-1462. https://doi.org/10.1038/ejcn.2017.57
23. Albayrak B, Süsgün S, Küçükakkaş O, Akbaş F, Yabaci A, Özçelik S. Investigating of relation between fibromyalgia syndrome and intestinal microbiota. Mikrobiyol Bul. 2021;55(2):146-160. https://doi.org/10.5578/mb.20219903
24. Duan R, Zhu S, Wang B, Duan L. Alterations of gut microbiota in patients with irritable bowel syndrome based on 16s rRNA-targeted sequencing: a systematic review. Clin Transl Gastroenterol. 2019;10(2):e00012. https://doi.org/10.14309/ctg.0000000000000012
25. Todor TS, Fukudo S. Systematic review and meta-analysis of calculating degree of comorbidity of irritable bowel syndrome with migraine. Biopsychosoc. Med. 2023;17(1):22. https://doi.org/10.1186/s13030-023-00275-4
26. Gupta S, Masand PS, Kaplan DS, Bhandary AN, Hendricks SE. The relationship between schizophrenia and irritable bowel syndrome (IBS). Schizophr Res. 1997;23(3):265-268. https://doi.org/10.1016/s0920-9964(96)00099-0
27. Lee YT, Hu L, Shen C, Huang M, Tsai SJ, Yang AC, et al. Risk of psychiatric disorders following irritable bowel syndrome: A nationwide population-based cohort study. PLoS One. 2015;10(7):e0133283. https://doi.org/10.1371/journal.pone.0133283
28. Islam Z, D'Silva A, Raman M, Nasser Y. The role of mind body interventions in the treatment of irritable bowel syndrome and fibromyalgia. Front Psychiatry. 2022;13:1076763. https://doi.org/10.3389/fpsyt.2022.1076763
29. Erdrich S, Hawrelak J, Myers S, Harnett J. A systematic review of the association between fibromyalgia and functional gastrointestinal disorders. Therap Adv Gastroenterol. 2020;13:1756284820977402. https://doi.org/10.1177/1756284820977402
30. Ståhlberg L, Palmquist E, Nordin S. Intolerance to environmental chemicals and sounds in irritable bowel syndrome: Explained by central sensitization? J. Health Psychol. 2016;23(10):1367-1377. https://doi.org/10.1177/1359105316656242
31. Kearney DJ, Kamp K, Storms M, Simpson TL. Prevalence of gastrointestinal symptoms and irritable bowel syndrome among individuals with symptomatic posttraumatic stress disorder. J Clin Gastroenterol. 2022;56(7):592-596. https://doi.org/10.1097/MCG.0000000000001670
32. Suzuki K, Suzuki S, Shiina T, Kobayashi S, Hirata K. Central sensitization in migraine: A narrative review. J Pain Res. 2022;15:2673-2682. https://doi.org/10.2147/JPR.S329280
33. Qin HY, Cheng CW, Tang XD, Bian ZX. Impact of psychological stress on irritable bowel syndrome. World J Gastroenterol. 2014;20(39):14126-14131. https://doi.org/10.3748/wjg.v20.i39.14126
34. Bolino CM, Bercik P. Pathogenic factors involved in the development of irritable bowel syndrome: Focus on a microbial role. Infect Dis Clin North Am. 2010;24(4):961-975. https://doi.org/10.1016/j.idc.2010.07.005
35. Aizawa E, Sato Y, Kochiyama T, Saito N, Izumiyama M, Morishita J, et al. Altered cognitive function of prefrontal cortex during error feedback in patients with irritable bowel syndrome, based on FMRI and dynamic causal modeling.

Gastroenterology. 2012;143(5):1188-1198. https://doi.org/10.1053/j.gastro.2012.07.104
36. Shulman RJ, Jarrett ME, Cain KC, Broussard EK, Heitkemper MM. Associations among gut permeability, inflammatory markers, and symptoms in patients with irritable bowel syndrome. J Gastroenterol. 2014;49(11):1467-1476. https://doi.org/10.1007/s00535-013-0919-6