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Innovative Approaches in Managing Irritable Bowel Syndrome: From Personalized Medicine to Gut Microbiome Therapies

Damini Kharb[1], Punita Kharb[2], Shagufta Jawaid[1], Abhijeet Singh[1]

[1]Doctorate in Pharmacy, Department of Pharmacy Practice, Shri Guru Ram Rai University, Dehradun, Uttarakhand, India.
[2] Department of General Medicine, Royal Metropolitan University, Bishkek, Kyrgyzstan.

Corresponding Author: Damini Kharb (ORCID ID – 0009-0007-5323-8492)

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ABSTRACT

Irritable Bowel Syndrome (IBS) is a multifaceted gastrointestinal disorder characterized by chronic abdominal pain, altered bowel habits, and a significant impact on quality of life. Recent advancements in understanding IBS pathophysiology have highlighted the role of the gut-brain axis, immune dysregulation, and gut microbiota imbalance, paving the way for innovative therapeutic approaches. This review explores personalized medicine and gut microbiome therapies as transformative strategies for IBS management. Personalized medicine leverages genetic, epigenetic, and clinical data to tailor treatments, ensuring optimal efficacy while minimizing adverse effects. Concurrently, gut microbiome-targeted therapies, including probiotics, prebiotics, fecal microbiota transplantation (FMT), and dietary modifications, aim to restore microbial equilibrium and alleviate symptoms. Emerging evidence suggests that these approaches address symptom variability and provide a long-term solution for managing IBS subtypes. Additionally, advancements in digital health tools, such as mobile applications and wearable devices, enhance symptom tracking and patient engagement. Despite promising results, challenges persist, including the need for standardized protocols, robust clinical trials, and cost-effective implementation. This review underscores the potential of integrating personalized medicine with microbiome-centered interventions to redefine IBS treatment paradigms. Future research should focus on unraveling IBS heterogeneity, refining therapeutic strategies, and addressing unmet patient needs for holistic care.

KEYWORDS: Irritable Bowel Syndrome (IBS), Personalized Medicine, Gut Microbiome Therapies, Gut-Brain Axis, Probiotics and Fecal Microbiota Transplantation.

I. INTRODUCTION

A. Inflammatory bowel disease

Inflammation of the gastrointestinal (GI) tract is a hallmark of recurrent, vulnerable-mediated, breed-in-the-bone illnesses known as inflammatory bowel disease (IBD).

Crohn's disease, which can affect any portion of the GI tract from the mouth to the anus continuously in a patchwork fashion and may involve all layers of the intestinal wall, is one of the fundamentals of IBD.

Ulcerative colitis is characterized by persistent inflammation restricted to the mucosal caste and localized to the colon and rectum. IBD was less prevalent in South America, Africa, and Asia.

However, these areas are currently experiencing a sharp increase in frequency,

which is ascribed to changes in lifestyle, industrialization, and urbanization (1). Frequency rates in developed nations vary between 300 and 500 cases per 100,000. IBD often appears between the ages of 15 and 30, with a 50–70% recurrent peak in frequency (2). Twenty to twenty-five percent of cases are nonage-onset IBD, which has unique clinical characteristics and consistently more aggressive symptoms. Women are more likely to suffer from Crohn's disease. Males are more likely to have ulcerative colitis (3).

B. Gut Bacteria

Gut bacteria significantly influence gastrointestinal health and defense system development and modulation (4). Disease initiation, progression, and flare-ups are influenced by dysbiosis or disturbances in the composition of gut microbes (5). Therapeutic approaches that target the microbiota to enhance illness outcomes and supplement conventional therapies hold great promise (6). Research is still being done to understand better how the immune system and microbiota engage in IBD and to create individualized strategies for reestablishing microbial balance (7).

- ❖ *Characteristics of Gut Microbiota Dysbiosis in IBD (8)*
  - o Reduced Microbial Diversity
  - o Imbalance Between Beneficial and Harmful Bacteria
  - o Altered Functional Profiles
  - o Imbalanced Gut Immune Responses

C. How to identify if it happens?

Crohn's disease: Right lower quadrant pain (ileum), non-bloody diarrhea (voluminous and watery diarrhea). Ulcerative colitis: Left lower quadrant pain(rectum), Tenesmus, Hematochezia (9).

D. How does it take place?

Numerous factors contribute to the growth of IBD. The number of causes and contributing factors for IBD is growing as the disease does (10). Genetic Susceptibility, Environmental Triggers, Gut Microbiota Dysbiosis, Immune System Dysregulation, Intestinal Barrier Dysfunction, Chronic Inflammation, Disease Triggers and Relapses, or other unidentified causes could be to blame (11). In light of recent studies:

- Genetic mutations increase susceptibility to IBD (12). For example: NOD2 (CARD15) mutations are strongly associated with Crohn's disease (13). IL23R mutations affect immune regulation and inflammation (14).
- Individuals with a family history of IBD are at significantly higher risk (15).
- High-fat, low-fiber, and processed diets can disrupt gut microbiota and promote inflammation (16).
- Smoking: Increases the risk of Crohn's disease. May be protective in ulcerative colitis (17).
- Antibiotics: Alter the gut microbiota, potentially triggering dysbiosis (18).
- Urbanization and Hygiene: Reduced exposure to diverse microbes may contribute to immune dysregulation (19).
- Stress, infections, changes in diet, or medication non-adherence can trigger disease flares (20).
- Dysbiosis may stimulate abnormal immune responses, contributing to chronic inflammation (21).
- Chronic epithelial injury perpetuates inflammation and disrupts normal healing (22).

E. Concise etiology of the disease:

Etiological factors – TH1 cells – IL-12, IL-13 – TH17 – IL-17 – TNF-alpha, INF-gamma - Increase Neutrophils, Granuloma, and transmural ulcers. TH2 – TNF-alpha – IL-4, IL-5 – Increase B-cells, Eosinophils, and submucosal ulcers.

F. Chemotherapy for the disease:

IBD treatment will depend on a wide range of variables; while the diseases and symptoms are generally the same, they vary to varying degrees from patient to patient (23). Age, general health, family history, and the severity of the patient's disease are among the factors (24).

Additional significant factors that need to be considered are the patient's tolerance for a particular medicine, the severity of complications and symptom worsening, expectations for the condition's course, and the stage of the disease (25).

II. RECOMMENDED MEDICATIONS

- ***5-ASA amino salicylates:***

5-ASA, commonly referred to as *mesalamine*, mainly acts on the gut mucosa by reducing inflammation (26).5. Instead of acting systemically, 5-ASA mostly acts locally in the intestinal lumen (27). 5-ASA functions as a free radical scavenger neutralizes ROS generated during inflammation, lowers oxidative stress, and stops intestinal lining tissue damage by inhibiting the COX and LOX enzymes, which lower the generation of inflammatory mediators (28). 5-ASA inhibits the activation of NF-κB, a transcription factor, and reduces the production of pro-inflammatory cytokines TNF-α, IL-1, and IL-6 (29). 5-ASA improves the integrity of the intestinal epithelial barrier by restoring it (30).

This minimizes the immune system's exposure to luminal antigens and lowers gut permeability (31). For better results, the British Society of Gastroenterology (BSG) recommends a dosage of 2-3 g per day in addition to 5-ASA enemas (32).

Prodrugs such as *sulfasalazine, balsalazide,* and *olsalazine* are designed to deliver 5-ASA to specific areas of the gut (33). These drugs are cleaved by gut bacteria, releasing 5-ASA at the site of inflammation (34). Prodrugs are strategically designed to: 1) Improve bioavailability. 2) Minimize side effects by targeting drug activation to specific tissues. 3) Allow for controlled release of the active agent (35).

- ***Corticosteroids:***

Corticosteroids exert their effects on IBD by Suppressing cytokine production and inflammatory signaling pathways (36). Inhibiting immune cell infiltration into the gut mucosa. Reducing prostaglandin and leukotriene production (37). Improving epithelial barrier function and preventing tissue damage (38). Corticosteroids are effective for induction of remission but are not recommended for maintenance therapy due to significant side effects and the risk of dependency (39).

For ulcerative colitis, the BSG recommends oral prednisolone at 40 mg daily, tapered over 6–8 weeks (40). For Crohn's disease, the American Gastroenterological Association (AGA) suggests intravenous corticosteroids at doses equivalent to 40–60 mg/day of methylprednisolone (41).

Immunomodulators:

- ***Thiopurines:*** Azathioprine (AZA), 6-Mercaptopurine (6-MP). metabolized to active metabolites (e.g., 6-thioguanine nucleotides) that Inhibit purine synthesis, interfere with DNA and RNA production in immune cells (42), Reduce the proliferation of lymphocytes (T and B cells), decrease immune-mediated inflammation in the gut (43), Promote T-cell apoptosis and reduce cytokine production (44). Maintenance of remission in Crohn's disease and ulcerative colitis (45). Steroid-sparing therapy. Thiopurines produce major side effects, hepatotoxicity, Myelosuppression, and Increased risk of infections and lymphoma on long-term use (46).
- ***Methotrexate (MTX):*** Inhibits dihydrofolate reductase, leading to reduced DNA synthesis and cell proliferation (47). Reduces T- and B-cell activity and the production of pro-inflammatory cytokines like IL-1, IL-6, and TNF-α. Exerts immunosuppressive effects, helping to control inflammation (48). Maintenance of remission in Crohn's disease. Often used in patient's intolerant to thiopurines. It produces major side effects as Hepatotoxicity, Bone marrow suppression, Gastrointestinal symptoms (49).
- ***Cyclosporine*:** Inhibits calcineurin, preventing T-cell activation by blocking the transcription of interleukin-2 (IL-2)

(50). Suppresses immune-mediated inflammation in the gut (51). Used in Severe ulcerative colitis refractory to corticosteroids (52). Short-term use to bridge therapy to other maintenance agents like thiopurines or biologics (53).

- ***Tacrolimus*:** Similar to cyclosporine, tacrolimus inhibits calcineurin, reducing T-cell activation and cytokine production (e.g., IL-2, IL-4). Rescue therapy for refractory Crohn's disease or ulcerative colitis (54).
- ***Janus Kinase (JAK) Inhibitors*:** Tofacitinib, Inhibits the JAK-STAT signaling pathway, which is crucial for the production of pro-inflammatory cytokines (e.g., IL-6, IL-12, IL-23, interferons) (55). Reduces immune cell activation and inflammation. It is used in Moderate to severe ulcerative colitis, and Emerging use in Crohn's disease (56).

- ***Biologic Therapies:***

It is indicated for Moderate to severe cases unresponsive to conventional therapy. Anti-TNF agents (e.g., infliximab) are used for induction and maintenance therapy (57). The standard regimen includes an induction phase with infusions at 0, 2, and 6 weeks, followed by maintenance every 8 weeks (58).

- ***Antibiotics:***

It is indicated for Acute pouchitis and certain complications in Crohn's disease (59). A two-week course of ciprofloxacin or metronidazole is recommended as first-line treatment for acute pouchitis (60).

III. SURGICAL THERAPY

- Crohn's Disease: INDICATIONS

1. Strictures causing obstruction.
2. Fistulas or abscesses.
3. Severe disease refractory to medical therapy.
4. Intestinal perforation.
5. Persistent bleeding (uncontrolled by endoscopic or medical treatment).
6. Growth failure in children due to malabsorption.

- Strictureplasty: Involves widening a narrowed segment of the intestine without removing it (61). Preserves bowel length, reducing the risk of short bowel syndrome (62).
- Segmental Resection: Removes the affected segment of the intestine (e.g., ileum or colon) while preserving as much bowel as possible (63).
- Ileocolic Resection: Removes the terminal ileum and adjacent colon (64). Frequently performed in Crohn's disease due to its common involvement in the terminal ileum (65).
- Fistula and Abscess Surgery: Drains abscesses or resects bowel segments with complex fistulas (66).
- Proctocolectomy with Permanent Ileostomy: Reserved for severe Crohn's disease involving the rectum or anus, where other treatments fail (67).
- *Ulcerative Colitis:* Indications

1. Medically refractory disease.
2. Toxic megacolon.
3. Severe bleeding (unresponsive to medical treatment).
4. Perforation of the colon.
5. Colorectal cancer or high-grade dysplasia detected on surveillance.
6. Growth failure or severe malnutrition in children.

- Proctocolectomy with Ileal Pouch-Anal Anastomosis (IPAA): The colon and rectum are removed, and a pouch (constructed from the small intestine) is connected to the anus (68). Maintains the ability to defecate without a permanent ostomy. Considered the gold standard for UC surgery in most cases (69).
- Total Proctocolectomy with End Ileostomy: The colon, rectum, and anus are removed, and a permanent ileostomy is created (70). Preferred in cases where IPAA is not feasible (e.g., poor sphincter function, anal disease) (71).
- Subtotal Colectomy with Ileostomy: Only the colon is removed, leaving the rectum in place (72). May be performed as an emergency procedure with a planned follow-up surgery (73).

IV. NUTRITIONAL THERAPY

Nutritional therapy can play a significant role in managing Inflammatory Bowel Disease (IBD), including Crohn's disease and ulcerative colitis (74). While it is not a cure, a well-planned diet can help control symptoms, prevent malnutrition, and maintain remission (75).

A. What should you add to your meal?

- Low-Fiber or Low-Residue Diet (during flare-ups): White rice, refined grains, cooked vegetables, skinless fruits, and lean proteins.
- High-Fiber Diet (during remission): Encouraged for some patients to maintain gut health if tolerated. Soluble fiber (e.g., oats, bananas) is often better tolerated (76).
- Low-FODMAP Diet: May reduce bloating and gas by avoiding fermentable sugars (like lactose, fructose, and sugar alcohols) (77).
- Elimination Diets: Identifies specific food triggers through supervised exclusion and gradual reintroduction of certain foods (78).
- Anti-Inflammatory Diet: Incorporates foods with natural anti-inflammatory properties, like omega-3-rich fish, turmeric, ginger, and green leafy vegetables (79).

B. What should you avoid eating?

- Spicy or fatty foods
- Caffeine
- Alcohol
- Carbonated beverages
- Nuts, seeds, and popcorn (if strictures or obstructions are present)

C. Key ideas for controlling your food intake:

Micronutrient Supplementation

- Iron: To address anemia, which is common due to chronic blood loss (80).
- Calcium & Vitamin D: To counteract bone loss, especially for those on corticosteroids (81).
- Vitamin B12: Particularly for Crohn's disease patients with ileal involvement or resections (82).
- Folate: Important if taking medications like methotrexate or sulfasalazine (83).
- Zinc and Magnesium: To replace losses from chronic diarrhea (84).

Probiotics and Prebiotics

- Probiotics: Some strains (e.g., Lactobacillus or Bifidobacterium) may help rebalance gut flora, particularly in ulcerative colitis (85).
- Prebiotics: Foods rich in resistant starches (e.g., bananas, garlic, onions) can feed beneficial bacteria but may not be tolerated during flares (86).

Exclusive Enteral Nutrition (EEN)

- A liquid-only diet using nutrient-rich formulas is often used in children with Crohn's disease to induce remission. It may reduce inflammation and promote healing.

Hydration

- Chronic diarrhea can lead to dehydration and electrolyte imbalances. Drink plenty of water, and consider oral rehydration solutions with electrolytes (87).

Omega-3 Fatty Acids

- Found in fish oil, flaxseeds, and walnuts, omega-3s may have mild anti-inflammatory effects, though evidence is mixed (88).

V. HERBAL THERAPY

- Curcumin (Turmeric): It have Anti-inflammatory, antioxidant property. Studies show curcumin may reduce symptoms and maintain remission in ulcerative colitis, particularly when combined with standard medications like mesalamine (89). Turmeric supplements standardized for curcumin or add turmeric to food. Dosages in studies often range from 2–3 grams/day (90).
- Aloe Vera: It has the Anti-inflammatory property, soothing to the gut lining (91). Aloe vera gel (oral) has shown promise in reducing symptoms of mild to moderate ulcerative colitis (92). Pure

aloe vera juice or gel, without added sugars or laxative compounds. Avoid if pregnant, breastfeeding, or if diarrhea worsens (due to potential laxative effects) (93).

- Boswellia Serrata (Indian Frankincense): Anti-inflammatory, particularly targeting leukotrienes involved in gut inflammation (94). Clinical trials have shown Boswellia to be effective in reducing symptoms of ulcerative colitis, comparable to mesalamine in some cases (95).
- Slippery Elm (Ulmus rubra): Mucilage-rich, soothing, and protective for the gut lining (96). Traditionally used for gut health, slippery elm may help reduce irritation and inflammation in the GI tract (97). Powdered slippery elm mixed with water or as a tea. Can reduce the absorption of other medications if taken simultaneously (98).
- Psyllium Husk: Soluble fiber that may soothe the gut and regulate bowel movements (99). Some studies suggest psyllium can help maintain remission in ulcerative colitis when combined with standard treatments (100). Mix psyllium husk powder with water; start with small amounts to gauge tolerance. Avoid if experiencing strictures or bowel obstructions (101).
- Licorice Root (Glycyrrhiza glabra): Anti-inflammatory, soothing for the digestive tract (102). Used traditionally for gut health; limited scientific data specifically for IBD (103). Prolonged use of licorice can cause elevated blood pressure and low potassium; consider deglycyrrhizinated licorice (DGL) to avoid these effects (104).
- Chamomile (Matricaria chamomilla): Anti-inflammatory, antispasmodic, and calming (105). Traditionally used for gut cramps and irritation; studies on IBD are limited but suggest it may ease mild symptoms. Rare allergic reactions in people sensitive to ragweed (106).
- Peppermint (Mentha piperita): Antispasmodic, may reduce bloating and cramping (107). Effective for irritable bowel syndrome (IBS) and may offer mild benefits for IBD symptoms like abdominal discomfort. Avoid in severe active disease or acid reflux (108) .
- Green Tea (Camellia sinensis): Rich in polyphenols with anti-inflammatory effects (109). Preliminary studies suggest green tea may help reduce inflammation in IBD (110). Brewed tea or standardized green tea extract. Excessive consumption may cause stomach upset or interfere with iron absorption (111).
- Wormwood (Artemisia absinthium): Anti-inflammatory, modulates immune responses (112). A few studies indicate wormwood may help reduce symptoms in Crohn's disease and improve quality of life (113).
- Ginger (Zingiber officinale): Anti-inflammatory, antioxidant, and aids digestion (114). May help with nausea and inflammation, though evidence for IBD is limited. High doses may cause stomach upset (115).
- Ashwagandha (Withania somnifera): Adaptogenic herb that may reduce stress-related inflammation (116). Limited direct evidence for IBD, but its anti-inflammatory effects may support overall health. Avoid if pregnant or breastfeeding (117).
- Milk Thistle (Silybum marianum): Antioxidant and liver-protective; may reduce inflammation (118). Limited evidence for IBD specifically, but may support liver health, especially for those on medications. Rare allergic reactions in people sensitive to daisies (119).

VI. PHYSICAL THERAPY

- Aerobic Activity: Walking, cycling, or swimming can improve overall fitness without putting excessive strain on the body (120).
- Strength Training: Low-resistance exercises to build strength while avoiding overexertion (121).

- Stretching and Flexibility Exercises: Yoga or targeted stretches to relieve joint stiffness and promote relaxation (122).
- Breathing Techniques: Diaphragmatic or deep breathing to reduce abdominal tension and stress (123).
- Pelvic Floor Exercises: Kegels or biofeedback therapy for those with bowel or urinary incontinence (124).

VII. PSYCHOLOGICAL THERAPY IN IBD

- Cognitive Behavioral Therapy (CBT):
  CBT is one of the most effective therapies for IBD-related mental health challenges (125). It helps patients identify and reframe negative thought patterns, reduce stress, and develop practical coping strategies (126).
- Mindfulness-Based Stress Reduction (MBSR):
  Mindfulness techniques like meditation and breathing exercises can help reduce stress and improve emotional regulation (127). MBSR is particularly useful in addressing the stress-gut connection in IBD.
- Acceptance and Commitment Therapy (ACT):
  ACT focuses on accepting difficult emotions and situations (like living with a chronic condition) while committing to actions that align with personal values, promoting psychological flexibility (128).
- Psychodynamic Therapy:
  This approach explores the emotional and subconscious roots of stress or distress, helping patients process unresolved issues or trauma that may impact their mental health (129).
- Biofeedback Therapy:
  Useful for stress management and symptoms like abdominal pain, biofeedback teaches patients how to control physiological functions like heart rate or muscle tension to promote relaxation (130).
- Supportive Counseling and Therapy:
  A supportive therapy approach allows patients to express their fears, frustrations, and concerns about living with IBD in a safe, non-judgmental environment (131).
- Group Therapy and Support Groups:
  Connecting with others who understand the challenges of IBD can reduce feelings of isolation, provide emotional support, and foster resilience (132).

VIII. Patient Counselling:

The benefits, choices, and treatment options that are available must be discussed with the IBD patient (133). It can be challenging to accept the challenges associated with this sickness, but with good counselling, appropriate procedures, and frequent treatments, it can be simply handled (134). They also need to be guided about the fundamental knowledge of how to deal with this disease to smooth out the symptoms.

A. Principles of the Counselling Method:

- Clinical pharmacy
- Proper medication adherence
- Regular and timely appointments
- Timely checking of nutritional imbalance
- Proper diet and avoid intake of harmful products like,
- toxins, smoke, etc.
- Daily activity with improved gut health
- Enough sleep and enough exercise.

B. Review of a clinical trial for IBD

- On January 15, 2025, the U.S. Food and Drug Administration (FDA) approved Eli Lilly's drug, Omvoh, for treating adults with moderate-to-severe Crohn's disease (135). This approval was based on a late-stage study where 53% of patients achieved remission after one year of treatment, compared to 36% on placebo. Previously, Omvoh was approved for moderate-to-severe active ulcerative colitis, marking it as a versatile option for IBD management.
- Teva Pharmaceutical, in partnership with Sanofi, reported significant efficacy of

their drug, duvakitug, in Phase 2 studies for both ulcerative colitis and Crohn's disease. The trials demonstrated remission rates ranging from 36.2% to 47.8% in ulcerative colitis patients and endoscopic response rates of 26.1% to 47.8% in Crohn's disease patients, outperforming placebo groups. These results position duvakitug as a potential leading treatment for IBD.

- Clinical trials are exploring vagus nerve stimulation (VNS) as a treatment for IBD. VNS, delivered non-invasively through the ear, has shown potential in modulating the brain-gut axis to reduce inflammation and alleviate symptoms such as pain and diarrhea. While not yet FDA-approved for IBD, early studies indicate that VNS could become an adjunctive therapy, especially for patients unresponsive to conventional medications.

Fecal Microbiota Transplantation (FMT)

Fecal Microbiota Transplantation (FMT), also known as a fecal transplant, is a medical procedure in which stool from a healthy donor is transplanted into the gastrointestinal (GI) tract of a patient (136). The goal is to restore the balance of the gut microbiota, which may have been disrupted due to diseases, infections, or antibiotic use.

- *What is FMT?*

FMT involves transferring stool, containing a complex mix of beneficial bacteria, viruses, and fungi, from a healthy donor to a recipient. The purpose is to reintroduce a diverse and balanced microbial community into the patient's gut.

- *How Does FMT Work?*

The gut microbiota all significantly impacts immunity, digestion, and general health. Disruptions in the gut microbiota, known as dysbiosis, can lead to various health issues. By transplanting a healthy microbiome into the recipient, FMT aims to:

- Outcompete harmful bacteria.
- Restore microbial diversity.
- Reduce inflammation and support gut healing.

C. Effects of IBD medicines on animal models

- In rodent models of IBD, corticosteroids improve colitis symptoms but can induce side effects such as weight gain and thymic atrophy (shrinkage of the thymus gland) (137).
- Studies on rats with experimentally induced colitis show that aminosalicylates reduce inflammatory markers and help maintain mucosal integrity.
- In mice models, these drugs show efficacy in suppressing inflammation but at the risk of significant toxicity, which necessitates careful dosing.
- In rats, methotrexate alleviates symptoms of chronic colitis but has a narrow therapeutic window with potential for significant side effects (138).
- In experimental colitis models, TNF-α inhibitors show significant efficacy in reducing disease severity and preventing further damage to the intestinal lining.
- Animal studies have shown that targeting IL-12/IL-23 pathways improves colitis symptoms by reducing Th1 and Th17 responses (139).
- In animal models of colitis, anti-integrin therapies help reduce chronic intestinal inflammation, with promising effects on mucosal healing.
- Animal studies on JAK inhibitors show significant improvements in intestinal inflammation and tissue healing. In murine models, sphingosine 1-phosphate receptor modulators show a reduction in inflammation and improved clinical outcomes (140).
- In animal models, metronidazole has been shown to reduce gut inflammation but may lead to altered gut microbiota.

D. New developments and trends in the disease:

- Tofacitinib (Xeljanz) and newer JAK inhibitors, like Filgotinib and Upadacitinib, are increasingly being

explored. These oral medications target intracellular signaling pathways involved in immune cell activation and inflammation. They are showing promise for both Crohn's disease and ulcerative colitis, especially in patients who do not respond to traditional biologics.

- Ustekinumab (Stelara), which targets the IL-12/IL-23 pathway, was recently approved for IBD. New anti-IL-23 agents, such as Guselkumab and Mirikizumab, are being tested.
- Ozanimod and Balovaptan are part of a newer class of drugs that work by modulating immune cell migration. These drugs are showing promise for reducing gut inflammation and improving disease control in both Crohn's and ulcerative colitis.
- Researchers are exploring how microRNAs (small RNA molecules involved in gene regulation) and epigenetic changes (changes in gene expression without altering DNA) influence IBD (141). These molecular changes may provide new diagnostic or therapeutic targets in the future.
- Mesenchymal Stem Cells (MSCs) are being investigated for their potential to modulate the immune response and promote tissue repair in IBD (142). Studies have shown that stem cells may help in reducing inflammation and promoting mucosal healing, particularly in ulcerative colitis.
- Innate Immunity and Gut Epithelial Cells: Research is increasingly focusing on the gut's innate immune system, specifically epithelial cell barriers and their interaction with microbial signals (143). Understanding how these barriers fail in IBD could lead to therapies aimed at restoring them.
- Telemedicine and mobile health applications are being increasingly integrated into IBD management, allowing for more personalized care (144). Digital tools help track symptoms, medication adherence, and quality of life in real time, making it easier for both patients and doctors to manage the disease remotely (145).

IX. CONCLUSION

IBS management has entered a transformative phase with significant advances in understanding its pathophysiology, new treatments on the horizon, and an increasing emphasis on personalized care. While the core treatment approach for IBS remains symptom-based, research into its multifactorial etiology—spanning motility, gut-brain interactions, the microbiome, and psychological factors—has paved the way for innovative therapies and non-pharmacological approaches that target the root causes. As clinical trials continue and new technologies emerge, the future of IBS treatment will likely be more effective, individualized, and holistic, aiming not only to alleviate symptoms but also to address the underlying causes of this complex disorder.

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REFERENCE

1. Sumedha, Singh S, Pathak PK. Intergenerational transitions in age at menarche: insights from Chandauli district, Uttar Pradesh, India. BMC Women's Health. 2025;25(1):9.
2. Khan I, Holubar SD. Operative Management of Small and Large Bowel Crohn's Disease. Surgical Clinics. 2025.
3. Shehab M, Alsayegh A, Alabdulhadi M, Snober S, Aleissa N, Alfadhli A. Relationship Between Patient Demographics and Biologic Therapy Use in Inflammatory Bowel Disease. A Single Center Cross-Sectional Study. JGH Open. 2025;9(1):e70092.
4. Saadh MJ, Ahmed HH, Al-Hussainy AF, Kaur I, Kumar A, Chahar M, et al. Bile's Hidden Weapon: Modulating the Microbiome and Tumor Microenvironment. Current Microbiology. 2025;82(1):25.
5. Konstantinou G, Konstantinou GN. Chronic Urticaria Through the Prism of Psycho-Neuro-Immunology: Another "Gordian Knot" to

Solve. PsychoNeuroImmunology: Volume 2: Interdisciplinary Approaches to Diseases: Springer; 2025. p. 655-84.
6. Yaqub MO, Jain A, Joseph CE, Edison LK. Microbiome-Driven Therapeutics: From Gut Health to Precision Medicine. Gastrointestinal Disorders. 2025;7(1):7.
7. Vallejos OP, Bueno SM, Kalergis AM. Probiotics in inflammatory bowel disease: microbial modulation and therapeutic prospects. Trends in Molecular Medicine. 2025.
8. Profir M, Enache RM, Roşu OA, Pavelescu LA, Creţoiu SM, Gaspar BS. Malnutrition and Its Influence on Gut sIgA–Microbiota Dynamics. Biomedicines. 2025;13(1):179.
9. Nagesh VK, Pulipaka SP, Bhuju R, Martinez E, Badam S, Nageswaran GA, et al. Management of gastrointestinal bleed in the intensive care setting, an updated literature review. World Journal of Critical Care Medicine. 2025;14(1).
10. Candel I, Wetwittayakhlang P, Bessissow T, Lakatos PL. The Importance of Post-Inflammatory Polyps (PIPs) in Colorectal Cancer Surveillance in Inflammatory Bowel Diseases. Journal of Clinical Medicine. 2025;14(2):333.
11. Warren[1] A, Nyavor Y, Beguelin A. Dangers of the chronic stress response in the context of the microbiota-gut-immune-brain. Gut Microbiota and Immunity in Health and Disease: dysbiosis and eubiosis's effects on the human body. 2025.
12. Petryszyn P, Zurakowski G, Dudkowiak R, Machowska M, Gruca A, Ekk-Cierniakowski P, et al. The N-Acetyltransferase 2 Polymorphism and Susceptibility to Inflammatory Bowel Disease: A Case–Control Study. Pharmacology Research & Perspectives. 2025;13(1):e70040.
13. Gibson G, Rioux JD, Cho JH, Haritunians T, Thoutam A, Abreu MT, et al. Eleven Grand Challenges for Inflammatory Bowel Disease Genetics and Genomics. Inflammatory Bowel Diseases. 2025;31(1):272-84.
14. Nguyen KHH, Le NV, Nguyen PH, Nguyen HHT, Hoang DM, Huynh CD. Human Immune System: Exploring Diversity Across Individuals And Populations. Heliyon. 2025.
15. Olivera PA, Martinez-Lozano H, Leibovitzh H, Xue M, Neustaeter A, Espin-Garcia O, et al. Healthy first-degree relatives from multiplex families vs simplex families have higher subclinical intestinal inflammation, a distinct fecal microbial signature, and harbor a higher risk of developing Crohn's disease. Gastroenterology. 2025;168(1):99-110. e2.
16. Ademosun AO, Ajeigbe OF, Ademosun MT, Ogunruku OO, Oboh G. Improving gut microbiome through diet rich in dietary fibre and polyphenols: The case for orange peels. Human Nutrition & Metabolism. 2025; 39:200295.
17. Wawan AHH, Aditya DMN. Ulcerative Colitis and Alcohol: Facts and Myths. Contemporary Research Analysis Journal. 2025;2(01):07-13.
18. Taitz JJ, Tan J, Ni D, Potier-Villette C, Grau G, Nanan R, et al. Antibiotic-mediated dysbiosis leads to activation of inflammatory pathways. Frontiers in Immunology. 2025; 15:1493991.
19. Varadarajan S, Herchet M, Mack M, Hofmann M, Bisle E, Sayer E, et al. Salutogenic Effects of Greenspace Exposure: An Integrated Biopsychological Perspective on Stress Regulation, Mental and Physical Health in the Urban Population. Open Psychology. 2025;7(1):20240003.
20. Almaraz ER, Salman-Monte TC, Calvo-Alen J, Ajo MJB, Álvaro JMÁ-G, Bernabeu P, et al. Doctor-Patient Communication in Systemic Lupus Erythematosus: Insights from the LupusVoice Study. SSM-Qualitative Research in Health. 2025:100528.
21. Chaudhary S, Kaur P, Singh TA, Bano KS, Vyas A, Mishra AK, et al. The dynamic crosslinking between gut microbiota and inflammation during aging: reviewing the nutritional and hormetic approaches against dysbiosis and inflammaging. Biogerontology. 2025;26(1):1.
22. Srinivasan D, Subbarayan R, Krishnan M, Balakrishna R, Adtani P, Shrestha R, et al. Radiation therapy-induced normal tissue damage: involvement of EMT pathways and role of FLASH-RT in reducing toxicities. Radiation and Environmental Biophysics. 2025:1-16.
23. Thomann AK, Schmitgen M-M, Stephan JC, Knoedler L-L, Gass A, Thomann PA, et al. Disease-State Dependent Associations Between Intrinsic Brain Function and Symptoms of Fatigue, Depression, and Anxiety in Crohn's Disease. Inflammatory Bowel Diseases. 2025:izae318.
24. Xia X, Deng H, Ren W, Yang L, Zhu Y, Liu Y, et al. Association between fasting blood glucose and psychotic symptoms in Chinese patients with first-episode drug-naïve major

depressive disorder. BMC Psychiatry. 2025;25(1):1-10.
25. Haedrich J, Huber R. Crohn's disease, irritable bowel syndrome, and chronic fatigue: the importance of communication and symptom management—a case report. Journal of Medical Case Reports. 2025;19(1):9.
26. Fousekis FS, Mpakogiannis K, Filis P, Skamnelos A, Christodoulou DK, Mauri D, et al. Exploring Chemoprevention in Colorectal Cancer for Patients with Inflammatory Bowel Disease: Mechanisms of Action and Clinical Aspects. Cancers. 2025;17(2):229.
27. Merir R, Baitiche M, Djerboua F, Lazzara G, Boutahala M. Experimental and computational insights into the design of pH-responsive sodium alginate-coated nanoparticles for targeted mesalazine delivery. Colloids and Surfaces A: Physicochemical and Engineering Aspects. 2025;707:135843.
28. Meenu M, Khandare K, Singh M, Kenyanya S, Sharma KP, Garg M. Salicylic Acid: Food, Functions, and Future. Plant Growth Regulators: Resilience for Sustainable Agriculture: Springer; 2024. p. 21-39.
29. Wang B, Li X, Hao W, Yu R, Wu H, Wang Q, et al. Isaria cicadae Miquel, as an edible fungus, against dextran sulfate sodium-induced ulcerative colitis in BALB/c mice. Journal of Future Foods. 2025;5(4):398-409.
30. Liang Y, Pang C, Ma L, Li J, Liao X, Li X, et al. Asperosaponin Vi Alleviates Dss-Induced Colitis and Intestinal Epithelial Repair by Suppressing Tfh Cell Via Inhibiting Stat3. Available at SSRN 5084370.
31. Marwaha K, Cain R, Asmis K, Czaplinski K, Holland N, Mayer DG, et al. Exploring the Complex Relationship Between Psychosocial Stress and the Gut Microbiome: Implications for Inflammation and Immune Modulation. Journal of Applied Physiology. 2025.
32. D'Amico F, Fasulo E, Jairath V, Paridaens K, Peyrin-Biroulet L, Danese S. Management and treatment optimization of patients with mild to moderate ulcerative colitis. Expert Review of Clinical Immunology. 2024;20(3):277-90.
33. Wang W, Chen Y, Wang Y, Wang Y, Zhang W, Dai K, et al. Azo-linked 5-ASA-coumarin prodrug: Fluorescent tracking for colonic drug release in UC treatment. Talanta. 2025;284:127277.
34. Wang J, Lv X, Li Y, Wu H, Chen M, Yu H, et al. A ROS-responsive hydrogel that targets inflamed mucosa to relieve ulcerative colitis by reversing intestinal mucosal barrier loss. Journal of Controlled Release. 2025;377:606-18.
35. Khurram I, Khan MU, Ibrahim S, Ghani MU, Amin I, Falzone L, et al. Thapsigargin and its prodrug derivatives: exploring novel approaches for targeted cancer therapy through calcium signaling disruption. Medical Oncology. 2025;42(1):1-21.
36. Zhang Y, Cao P, Qin D, Zhao Y, Chen X, Ma P. Anti-inflammatory, anti-colitis, and antioxidant effects of columbianadin against DSS-induced ulcerative colitis in rats via alteration of HO-1/Nrf2 and TLR4-NF-κB signaling pathway. Inflammopharmacology. 2025:1-12.
37. Deng Q, Yao X, Fang S, Sun Y, Liu L, Li C, et al. Mast cell-mediated microRNA functioning in immune regulation and disease pathophysiology. Clinical and Experimental Medicine. 2025;25(1):38.
38. Jang H, Kim H, Oh S-H, Son Y, Lee RM, Nah S-Y, et al. Gintonin enhances epithelial barrier function by activating NRF2 pathway in radiation-induced intestinal injury. Journal of Ginseng Research. 2025.
39. De D, Mehta H, Shah S, Ajithkumar K, Barua S, Chandrashekar L, et al. Consensus Based Indian Guidelines for the Management of Pemphigus Vulgaris and Pemphigus Foliaceous. Indian Dermatology Online Journal. 2025;16(1):3-24.
40. Bhat S, Choi D. Guselkumab: A New Therapeutic Option for the Treatment of Moderately to Severely Active Ulcerative Colitis. Annals of Pharmacotherapy. 2025:10600280241305441.
41. Siddiqui MT, Kasiraj R, Naseer M. Medical Management of Ulcerative Colitis and Crohn's Disease—Strategies for Inducing and Maintaining Remission. Surgical Clinics. 2025.
42. Primorac D, Bach-Rojecky L. Pharmacogenomics in Gastroenterology. Pharmacogenomics in Clinical Practice: Springer; 2024. p. 239-52.
43. Takashima S, Sharma R, Chang W, Calafiore M, Fu Y-Y, Jansen SA, et al. STAT1 regulates immune-mediated intestinal stem cell proliferation and epithelial regeneration. Nature Communications. 2025;16(1):138.
44. Marei HE, Bedair K, Hasan A, Al-Mansoori L, Caratelli S, Sconocchia G, et al. Current status and innovative developments of CAR-T-cell therapy for the treatment of breast cancer. Cancer Cell International. 2025;25(1):3.

45. Gros B, Targownik LE. Guselkumab in the IL-23 inhibition landscape for ulcerative colitis. The Lancet. 2025;405(10472):2-3.
46. Rathi G, Shamkuwar PB, Rathi K, Ranazunjare R, Kulkarni S. Contemporary and prospective use of azathioprine (AZA) in viral, rheumatic, and dermatological disorders: a review of pharmacogenomic and nanotechnology applications. Naunyn-Schmiedeberg's Archives of Pharmacology. 2024:1-15.
47. Ghosh M, Gupta PK, Jena S, Rana S. The interaction of methotrexate with the human C5a and its potential therapeutic implications. Computational Biology and Chemistry. 2025;114:108283.
48. Wu S, Cao Z, Lu R, Zhang Z, Sethi G, You Y. Interleukin-6 (IL-6)-associated tumor microenvironment remodelling and cancer immunotherapy. Cytokine & Growth Factor Reviews. 2025.
49. Butler T, Bexfield N. Update on the treatment of canine liver disease. In Practice. 2025;47(1):4-15.
50. Du Y, Wang L, Zhou J, Hong W, Cai X, Ma H, et al. Identification of a dual JAK3/TEC family kinase inhibitor for atopic dermatitis therapy. Biochemical Pharmacology. 2025:116740.
51. Oportus J, Hojman L, Gonzalez V, Karsulovic C. Soluble IL-2R as a Marker of T Cell Activation in Immune-Mediated Diseases: Review and Case-Based Interpretation. Lymphatics. 2025;3(1):1.
52. Hoffert Y, Ferrante M, Verstockt B, Dreesen E. Intensified infliximab induction therapy for steroid-refractory acute severe ulcerative colitis. The Lancet Gastroenterology & Hepatology. 2025;10(1):18-9.
53. Jin X, Sun K, Wang L, Shen H, Ma D, Shen T, et al. Efficacy and safety of dual-targeted therapy for inflammatory bowel disease: a retrospective multicenter study in China. Therapeutic Advances in Gastroenterology. 2025;18:17562848241307598.
54. Bertin L, Crepaldi M, Zanconato M, Lorenzon G, Maniero D, De Barba C, et al. Refractory Crohn's disease: perspectives, unmet needs and innovations. Clinical and Experimental Gastroenterology. 2024:261-315.
55. Paolino G, Valenti M, Carugno A, Bianco M, Didona D, Di Nicola M, et al. Serum Lipids Alterations in Patients Under Systemic JAK Inhibitors Treatments in Dermatology: Clinical Aspects and Management. Medicina. 2025;61(1).
56. Kiilerich KF, Andresen T, Darbani B, Gregersen LH, Liljensøe A, Bennike TB, et al. Advancing Inflammatory Bowel Disease Treatment by Targeting the Innate Immune System and Precision Drug Delivery. International Journal of Molecular Sciences. 2025;26(2):575.
57. Naganuma M, Takeno M, Çelik AF, Moots R, Pinton P, Hisamatsu T. Assessment of IL-6 Pathway Inhibition in Gastrointestinal Behçet's Disease from Immunological and Clinical Perspectives. Biomedicines. 2025;13(1):247.
58. de Graav GN, Udomkarnjananun S, Baan CC, Reinders ME, Roodnat JI, de Winter BC, et al. New developments and therapeutic drug monitoring options in costimulatory blockade in solid organ transplantation: a systematic critical review. Therapeutic Drug Monitoring. 2025;47(1):64-76.
59. Akiyama S, Barnes EL, Onoda T, Ishikawa N, Shiroyama M, Ito Y, et al. Endoscopic assessment of the J pouch in ulcerative colitis: A narrative review. DEN open. 2025;5(1):e373.
60. Jha DK, Mishra S, Dutta U, Sharma V. Antibiotics for inflammatory bowel disease: Current status. Indian Journal of Gastroenterology. 2024;43(1):145-59.
61. Erozkan K, Costedio MM, DeRoss AL. Operative Management of Inflammatory Bowel Disease in Children. Surgical Clinics. 2025.
62. Dagorno C, Montalva L, Capito C, Lavrand F, Guinot A, Cocci SDN, et al. Serial Transverse Enteroplasty (STEP) for Short Bowel Syndrome (SBS) in Children: A Multicenter Study on Long-term Outcomes. Journal of Pediatric Surgery. 2025;60(1):161909.
63. Reynolds IS, McNamara DA. Colorectal Surgery. Hamilton Bailey's Emergency Surgery: CRC Press; 2025. p. 556-81.
64. Pérez-Restrepo MJ, Moya-Ortiz CA, Eslait-Olaciregui S, Báez-López DK, Páez N, Nieto DAP, et al. Negative-Pressure Wound Therapy: A Novel Approach for Terminal Ileum Anastomosis Success. The American Journal of Case Reports. 2025;26:e945745.
65. Baker ME, Feldman M, Ream J. The Essential Role of Imaging in the Diagnosis, Characterization, and Treatment of Patients with Crohn's Disease. Surgical Clinics. 2025.
66. Misar A, Litchinko A, Bloget F, Chilcott MJ, Egger B. Rare Enterohepatic Fistula in Crohn's Disease: Case Analysis and Literature

Synthesis. The American Journal of Case Reports. 2025;26:e945701.
67. Powers JC, Dester E, Schleicher M, Cohen B, Lashner B, Ivanov AI, et al. Medical, Endoscopic, and Surgical Treatments for Rectal Cuffitis in IBD Patients with an Ileal Pouch-Anal Anastomosis: A Narrative Review. Digestive Diseases and Sciences. 2025:1-21.
68. Stephens I, Byrnes K, McCawley N, Burke J. Preoperative anorectal manometry as a predictor of function after ileal pouch anal anastomosis: a systematic review and meta-analysis. Techniques in Coloproctology. 2025;29(1):1.
69. Hill R, Travis S, Ardalan Z. Navigating Chronic Pouchitis: Pathogenesis, Diagnosis, and Management. Gastroenterology & Hepatology. 2025;21(1):47.
70. Shibutani M, Kasashima H, Fukuoka T, Maeda K. Surgical Treatment and Postoperative Surveillance for Familial Adenomatous Polyposis. 2025.
71. Moon J, Monton O, Smith A, Demian M, Sabboobeh S, Garfinkle R, et al. The impact of an interactive online informational and peer support application (app) for patients with low anterior resection syndrome (LARS) on quality of life: a multicenter randomized controlled trial. Surgical Endoscopy. 2025:1-10.
72. Grigorie TR, Potlog G, Alexandrescu ST. Lynch Syndrome—Impact of the Type of Deficient Mismatch Repair Gene Mutation on Diagnosis, Clinical Presentation, Surveillance and Therapeutic Approaches. Medicina. 2025;61(1):120.
73. Sarbay İ, Yıldız F, Kendir V. Non-intubated single surgeon single-port video-assisted thoracic surgery: A retrospective evaluation of the first experiences in a secondary care hospital. Journal of Surgical Arts. 2025;18(1):1-5.
74. Tomaszewska WM, Siudziński P, Łyko M, Skoczylas A, Kurasz J, Maj W, et al. The Role of Vitamin D in the Pathomechanism of Inflammatory Bowel Disease (IBD) and its Therapeutic Implications-a literature review. Journal of Education, Health and Sport. 2025;77:56782-.
75. Moon JS, Kang S, Choi JH, Lee KA, Moon JH, Chon S, et al. 2023 clinical practice guidelines for diabetes management in Korea: full version recommendation of the Korean diabetes association. Diabetes & Metabolism Journal. 2024;48(4):546-708.
76. Jadhav SP, Shah UB, Shelke K. Current Facts about Clean Label Food Products. Food Intolerances: CRC Press; 2025. p. 162-200.
77. Khan Z, Muhammad SA, Amin MS, Gul A. The Efficacy of the Low-FODMAP (Fermentable Oligosaccharides, Disaccharides, Monosaccharides, and Polyols) Diet in Irritable Bowel Syndrome: A Systematic Review and Meta-Analysis. Cureus. 2025;17(1).
78. Raja S, Teitelbaum JE, Pereira K, Guli K, Schosheim A. Efficacy of low FODMAP diet in pediatric patients with disorders of gut–brain interaction. JPGN Reports. 2025.
79. Bansal K, Sundram S, Malviya R. Herbal Components Inspiring Current Lifestyle Disease Treatment: Role of Nutraceuticals. Current Drug Research Reviews Formerly: Current Drug Abuse Reviews. 2024;16(2):111-27.
80. Obeagu EI, Obeagu GU, Ukibe NR, Oyebadejo SA. Anemia, iron, and HIV: decoding the interconnected pathways: A review. Medicine. 2024;103(2):e36937.
81. Papadopoulou SNA, Anastasiou EA, Adamantidi T, Ofrydopoulou A, Letsiou S, Tsoupras A. A Comprehensive Review on the Beneficial Roles of Vitamin D in Skin Health as a Bio-Functional Ingredient in Nutricosmetic, Cosmeceutical, and Cosmetic Applications. Applied Sciences. 2025;15(2):796.
82. Chirayath S, Bahirwani J, Pandey A, Memel Z, Park S, Schneider Y. Inpatient Nutritional Considerations in Inflammatory Bowel Disease. Current Gastroenterology Reports. 2025;27(1):1-11.
83. Nikose A, Patil S, Kadhe N, Aishwarya N, KADHE N. Understanding the Dual Challenge: Adverse Drug Reactions and Adherence in Rheumatoid Arthritis Treatment. Cureus. 2025;17(1).
84. Rodrigues SS, Bocchi M, de Oliveira DM, Fernandes EV. Importance of trace elements in the immunometabolic health of people living with HIV/AIDS: a literature review. Molecular Biology Reports. 2025;52(1):1-15.
85. Otten BMJ. The impact of prebiotics, probiotics, and gut-derived metabolites on intestinal health and skeletal muscle metabolic and oxidative capacity. 2025.
86. Costa A, Lucarini E. Treating chronic stress and chronic pain by manipulating gut microbiota with diet: can we kill two birds with one stone? Nutritional Neuroscience. 2024:1-24.
87. Manfredi M, Marcianò G, Iuliano S, Leo F, Gallelli L. Racecadotril in the management of diarrhea: an underestimated therapeutic option?

Therapeutic Advances in Gastroenterology. 2025;18:17562848241310423.
88. Jäger R, Heileson JL, Abou Sawan S, Dickerson BL, Leonard M, Kreider RB, et al. International Society of Sports Nutrition Position Stand: Long-Chain Omega-3 Polyunsaturated Fatty Acids. Journal of the International Society of Sports Nutrition. 2025;22(1):2441775.
89. De Leo V, Catucci L, Maurelli AM, Daniello V, Conese M, Di Gioia S. Liposomes and Exosome-Like Nanoparticles for Curcumin Delivery to the Gut and to Treat Inflammatory Bowel Disease. Advances in Novel Phytopharmaceuticals: CRC Press; 2025. p. 134-59.
90. Limketkai BN, Iyengar P. The Use of Curcumin in Ulcerative Colitis: Current Evidence and Practical Applications. PRACTICAL GASTROENTEROLOGY. 2024:19.
91. Raj A, Kumari R, Rani A, Srivastava SP, Ahmad I, Viswakarma K, et al. A Review: Herbal Remedies Used for The Treatment of Mouth Ulcer. Dialogues in Cardiovascular Medicine. 2025;30:5-10.
92. Nguyen TQ, Van Pham T, Andriana Y, Truong MN. Cordyceps militaris-Derived Bioactive Gels: Therapeutic and Anti-Aging Applications in Dermatology. Gels. 2025;11(1):33.
93. Birajdar KM, Chaudhari RS, Chaudhari RS, Birangane R, Parkarwar P, Kulkarni A. Alternative And Complementary Treatment Modalities In Oral Lesions: OrangeBooks Publication; 2025.
94. Jain D, Singh K, Gupta P, Gupta JK, Sahu PK, Dwivedi S, et al. Exploring Synergistic Benefits and Clinical Efficacy of Turmeric in Management of Inflammatory and Chronic Diseases: A Traditional Chinese Medicine Based Review. Pharmacological Research-Modern Chinese Medicine. 2025:100572.
95. Dzwonkowski M, Bahirwani J, Rollins S, Muratore A, Christian V, Schneider Y. Selected Use of Complementary and Alternative Medicine (CAM) Agents in IBD. Current Gastroenterology Reports. 2025;27(1):1-9.
96. Bellebuono H. An Herbalist's Guide to Formulary: The Art & Science of Creating Effective Herbal Remedies: Llewellyn Worldwide; 2017.
97. Leung AK, Lam JM, Barankin B, Leong KF, Hon KL. Group A β-hemolytic streptococcal pharyngitis: an updated review. Current Pediatric Reviews. 2025;21(1):2-17.
98. Woolf V. Orlando: A biography: Lindhardt og Ringhof; 2025.
99. Dellschaft N, Murray K, Ren Y, Marciani L, Gowland P, Spiller R, et al. Assessing Water Content of the Human Colonic Chyme Using the MRI Parameter T1: A Key Biomarker of Colonic Function. Neurogastroenterology & Motility. 2025:e14999.
100. Islam Z, Bhat KA, Ahmad F, Islam A, Syed J, John A, et al. Plant-based approaches for treating celiac and Crohn's diseases: Current insights. Role of Medicinal Plants in. 2025:155.
101. Cheng J, Guo M, Wang C. Dietary fiber and dietary fiber-rich foods. Functional Foods: Elsevier; 2025. p. 55-103.
102. Obied SM. Evaluation of Prophylactic Effect of Aqueous Liquorice Root Extract Against Gastric Ulcer in Rats Induced by Ethanol. Egyptian Journal of Veterinary Sciences. 2025;56(6):1135-42.
103. Tang J, Hu Y, Fang J, Zhu W, Xu W, Yu D, et al. Huanglian Ejiao Decoction Alleviates Ulcerative Colitis in Mice Through Regulating the Gut Microbiota and Inhibiting the Ratio of Th1 and Th2 Cells. Drug Design, Development and Therapy. 2025:303-24.
104. Massoud AMA, El Ebiary FH, Abd Elwahab NG, El-Waseef AE-DA. The Effect of Fermented Deglycyrrhizinated Liquorice Extract on the Structure of the Renal Cortex in Experimentally Induced Diabetes Mellitus in Rats: Histopathological Study. Ain Shams Medical Journal. 2024;75(2):443-67.
105. Feszterová M, Jakubčinová J, Ďuráková A. ANALYSIS OF RISK ELEMENTS IN HERBAL TEA SAMPLES. Journal of microbiology, biotechnology and food sciences. 2025:e11740-e.
106. Ungerer JT. Grow, Gather, Heal: Unleashing the Power of Feverfew: An In-Depth Exploration of Feverfew's History, Folk and Traditional Uses, Medicinal Benefits, and Cultivating Your Own at Home: John T. Ungerer; 2024.
107. Hota D, Srinivasan A, Panigrahi MK, Dalua SS, Tiwari P, Valavan R. A clinical study on the efficacy and safety of poly-herbal formulation in managing functional dyspepsia. Phytomedicine Plus. 2025;5(1):100671.
108. Jain A, Ramchandani S, Bhatia S. Gastrointestinal symptoms and disorders of gut-brain interaction in pregnancy. Indian Journal of Gastroenterology. 2025:1-13.
109. Kim MJ, Yang YJ, Min G-Y, Heo JW, Son JD, You YZ, et al. Anti-inflammatory and

antioxidant properties of Camellia sinensis L. extract as a potential therapeutic for atopic dermatitis through NF-κB pathway inhibition. Scientific Reports. 2025;15(1):2371.
110. Diaz MJ, Tran JT, Rose D, Wei A, Lakshmipathy D, Lipner SR. Dietary Interventions, Supplements, and Plant-Derived Compounds for Adjunct Vitiligo Management: A Review of the Literature. Nutrients. 2025;17(2):357.
111. Naeem M. Role of Nutrition in the Management of Inflammatory Bowel Disease. 2025.
112. Maqbool I, Rather HA, Bhat KA, Ayaz A, Ahmad J, Mohiuddin I, et al. Medicinal plants and other autoimmune diseases. Role of Medicinal Plants in. 2025:291.
113. Sabarathinam S. Unveiling the therapeutic potential of Quercetin and its metabolite (Q3OG) for targeting inflammatory pathways in Crohn's disease: A network pharmacology and molecular dynamics approach. Human Gene. 2025;43:201372.
114. Verma A, Meshram R. Ethno Medicinal Values of Ginger (Zingiber Officinale): A Systematic Review.
115. Estes-Doetsch H, Radler DR, Patusco R. Iron Replacement in Patients With Inflammatory Bowel Disease and Nonanemic Iron Deficiency: What Is the Clinical Significance? Topics in Clinical Nutrition. 2025;40(1):62-74.
116. Chary JS, Sharma A. Withania Somnifera: A Rasayana Herb for Sustainable Management of Human Health and Overall Well-Being. Advanced Green Technology for Environmental Sustainability and Circular Economy: CRC Press; 2025. p. 33-47.
117. Chen W, Ma Q, Li Y, Wei L, Zhang Z, Khan A, et al. Butyrate Supplementation Improves Intestinal Health and Growth Performance in Livestock: A Review. Biomolecules. 2025;15(1):85.
118. Li Y, Li H, Sun M, Chen H, Xiao Y, Wang J, et al. Silibinin alleviates acute liver failure by modulating AKT/GSK3β/Nrf2/GPX4 pathway. Naunyn-Schmiedeberg's Archives of Pharmacology. 2025:1-15.
119. Dashputre NL, Laddha UD, Ahire ED, Bandawane DD, Patil SB, Kadam JD. Overview of Chronic Diseases. Novel Drug Delivery Systems in the Management of Chronic Diseases: Apple Academic Press; 2025. p. 3-35.
120. Walawalkar B. B Well Forever: Blue Rose Publishers; 2025.
121. Bonilla C, Kilian JR, Herron RL. A Flexible Training Approach to Improving Concurrent Training Outcomes in Remote Trainees. International Journal of Exercise Science. 2025;18(8):43-55.
122. Mondal H, Mondal S, Baidya C, Juhi A. The Power of Micro-Yoga in the Workplace. Impact of Yoga and Proper Diet on Cardiopulmonary Function: IGI Global Scientific Publishing; 2025. p. 33-68.
123. Tsakona P, Kitsatis I, Apostolou T, Papadopoulou O, Hristara-Papadopoulou A. The Effect of Diaphragmatic Breathing as a Complementary Therapeutic Strategy in Stress of Children and Teenagers 6–18 Years Old. Children. 2025;12(1):59.
124. Swartz H. Biodigital Literacy through Intimate Data: User Perceptions of FemTech and Pelvic Floor Training Devices. Communication Design Quarterly Review. 2025;12(3):74-85.
125. Brenner EJ, Grewe ME, Berenblum Tobi C, Bryant AG, Dubinsky MC, Zhang X, et al. Perspectives on Contraception, Pregnancy, and Reproductive Health Counseling from Young Women With Inflammatory Bowel Disease. Crohn's & Colitis 360. 2025;7(1):otae078.
126. Tsolakis P. Beck's Cognitive Model of Depression: Evolution, Modern Evidence and Critical Appraisal. Psychology. 2025;16(1):12-25.
127. Kumari P, Sahu SK. From Chaos to Calm: Using Meditation to Navigate Women's Work-life Balance Challenges. Asian Journal of Economics, Business and Accounting. 2025;25(1):138-46.
128. Chernyshov VK. ACT Workbook for Beginners: Step-by-Step Acceptance and Commitment Therapy Strategies, Exercises, and Real-Life Examples for Mental Wellness: Vicki Katrina Chernyshov; 2025.
129. Leiderman LM, Buchele BJ. Why Group in the Treatment of Trauma. Advances in Group Therapy Trauma Treatment. 2025:146.
130. Pruneti C, Fiduccia A, Guidotti S. Top-level managers' psychophysical recovery investigated through different psychophysiological parameters benefits from training based on muscle relaxation and self-monitoring of HRV-biofeedback. NeuroRegulation. 2024;11(1):43-.
131. Pourkazem T, Ghazanfari A, Ahmadi R. Comparison of the Effectiveness of Mindfulness-Based Stress Reduction and Compassion-Focused Treatment on the Severity of Gastrointestinal Symptoms in Patients with

Irritable Bowel Syndrome. Middle East Journal of Digestive Diseases. 2024;16(1).
132. Jakubczyk P, Widera P, Helis J, Michalik M, Buczek A, Bigajski H, et al. The Influence of Physical Activity on Inflammatory Markers, Intestinal Microbiota Composition and Disease Activity in Inflammatory Bowel Disease. Quality in Sport. 2025;37:57087-.
133. Lundekvam JA, Høivik ML, Anisdahl K, Småstuen MC, Warren DJ, Bolstad N, et al. Tumour necrosis factor inhibitors in Ulcerative colitis: real-world data on Therapeutic drug monitoring and evaluation of current treatment targets (STRIDE II). Annals of Medicine. 2025;57(1):2424447.
134. Kanjia MK, Jooste EH, Illig M, Neifeld Capps J, Eisner C, Fan SZ, et al. Optimizing the anesthetic care of patients with aromatic l-amino acid decarboxylase deficiency. Pediatric Anesthesia. 2025;35(2):99-106.
135. White C, Irving PM. An evaluation of mirikizumab for the treatment of ulcerative colitis. Expert Opinion on Biological Therapy. 2024;24(11):1199-206.
136. Thorndal C, Kragsnaes MS, Nilsson AC, Holm DK, dePont Christensen R, Ellingsen T, et al. Safety and efficacy of faecal microbiota transplantation in patients with acute uncomplicated diverticulitis: study protocol for a randomised placebo-controlled trial. Therapeutic Advances in Gastroenterology. 2025;18:17562848241309868.
137. Mazzari G. Facilitating stress resilience by "Old friends": Immunization with Mycobacterium vaccae prevents the negative effects of early life stress on chronic stress vulnerability during adulthood. 2024.
138. Shaban SF, Abdel-Fattah EA, Ali MM, Dessouky AA. The therapeutic efficacy of adipose mesenchymal stem cell-derived microvesicles versus infliximab in a dextran sodium sulfate induced ulcerative colitis rat model. Ultrastructural Pathology. 2024; 48(6):526-49.
139. Vats K, Tian H, Singh K, Tyurina YY, Sparvero LJ, Tyurin VA, et al. Ferroptosis of select skin epithelial cells initiates and maintains chronic systemic immune-mediated psoriatic disease. The Journal of Clinical Investigation. 2025;135(2).
140. Chen L, Ye Z, Li J, Wang L, Chen Y, Yu M, et al. Gut bacteria Prevotellaceae related lithocholic acid metabolism promotes colonic inflammation. Journal of Translational Medicine. 2025;23(1):55.
141. Golan-Gerstl R, Ben Ya'acov A, Musseri M, Goldenberg R, Chammah Y, Cherki T, et al. Expression Profile of MicroRNAs in Breast Milk of Women With Inflammatory Bowel Disease: Correlation With Disease Activity and Medical Treatments. Inflammatory Bowel Diseases. 2025:izae290.
142. Zhao D-Z, Yang R-L, Wei H-X, Yang K, Yang Y-B, Wang N-X, et al. Advances in the immunomodulatory mechanism of mesenchymal stromal/stem cells on periodontal tissue regeneration. Frontiers in Immunology. 2025;15:1449411.
143. Jones K, de Brito CB, Byndloss MX. Metabolic tug-of-war: Microbial metabolism shapes colonization resistance against enteric pathogens. Cell Chemical Biology. 2025;32(1):46-60.
144. Parveen S, Amjad M, Rauf SA, Arbab S, Jamalvi SA, Saleem SE-U-R, et al. Surgical decision-making in the digital age: the role of telemedicine–a narrative review. Annals of Medicine and Surgery. 2025;87(1):242-9.
145. Yadav NS, Goar VK. IoT in Healthcare and Telemedicine: Revolutionizing Patient Care and Medical Practices. Scalable Modeling and Efficient Management of IoT Applications: IGI Global; 2025. p. 19-58.

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