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## INTERPRETIVE GUIDE

**GI-MAP®** – Unparalleled DNA-Based Stool Testing

*Our mission: to deliver innovative, accurate and clinically relevant diagnostic testing in a timely and cost-effective manner*



GI Microbial Assay Plus

# FIRST OF ALL THANK YOU FOR CONSIDERING US!

"At Diagnostic Solutions Laboratory, we're not content with the range of clinical testing currently available to practitioners. We believe that every patient should achieve optimal health, and we're driven to give clinicians the tools to do so. Our mission, therefore, is to use our resources to bring the most advanced, innovative, and clinically relevant testing to healthcare providers worldwide."

**Tony Hoffman**  
President and CEO

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**GI-MAP®**

# INTRODUCTION

The Gastrointestinal Microbial Assay Plus (GI-MAP®) is an innovative clinical tool that measures gastrointestinal microbiota DNA from a single stool sample with state of the art, quantitative polymerase chain reaction (*qPCR* or *real-time PCR*) technology.

The GI-MAP was designed to detect microbes that may be disturbing normal microbial balance or contributing to illness as well as indicators of digestion, absorption, inflammation, and immune function. The following guide may be useful for understanding the nature of each of the microorganisms found on the GI-MAP, as well as clinical implications and treatment guidelines.

*Please see the GI-MAP white paper for additional, fully referenced, information.*

# HOW TO READ THE REPORT

GI-MAP quantifies bacteria, fungi, viruses, and parasites using qPCR. This is a leap forward from older methodologies that report only positive or negative. Results are reported as colony forming units per gram of stool (CFU/g). One CFU is roughly equivalent to one microorganism (*or one cell*). Results are expressed in standard scientific notation. A reported result of 3.5e7 is equivalent to  $3.5 \times 10^7$  CFU/g, which equals 35,000,000 CFU/g, or 35 million CFU per gram of stool.

PATHOGENS			
BACTERIAL PATHOGENS	Result	Reference	
Campylobacter	< dl	< 1.00e3	
C. difficile Toxin A	1.21e5 High †	< 1.00e3	

**Figure 1.** The normal reference range for *C. difficile*, Toxin A is 0–1,000 CFU/g. The patient's result is very high at  $1.21 \times 10^5$ , or 121,000 CFU/g.

Reference ranges were developed using known positive, diseased samples to construct cut off values that distinguish disease-causing amounts of pathogenic and opportunistic microbes. Reference ranges for the pathogens were correlated with an FDA cleared assay for GI pathogens. The GI-MAP is capable of detecting as low as 0.1 cell per gram of stool.

**Table 1.** Scientific notation; a basic reference table.

1.0e1	$1 \times 10^1$	10	Ten
1.0e2	$1 \times 10^2$	100	One hundred
1.0e3	$1 \times 10^3$	1,000	One thousand
1.0e4	$1 \times 10^4$	10,000	Ten thousand
1.0e5	$1 \times 10^5$	100,000	One hundred thousand
1.0e6	$1 \times 10^6$	1,000,000	One million

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# | PATHOGENS

The GI-MAP includes pathogens (*bacterial, parasitic, and viral*) commonly known to cause intestinal gastroenteritis. It's important to note that not all individuals with positive findings for pathogens will present with symptoms. Many factors, including the health of the individual, the transient nature of some pathogens, and the presence and expression of virulence factors all contribute to an individual's symptoms. Toxins are a type of virulence factor produced by certain pathogens. Since GI-MAP is a DNA-based test, results reflect the levels of pathogenic strains carrying the toxin genes, not the levels of any toxins that may be produced.

## | BACTERIAL PATHOGENS

### *Campylobacter*

- **Epidemiology**

- » One of the most common causes of foodborne illness in the U.S.
- » Fecal contamination of poultry and water

- **Clinical Implications**

- » May be infectious at very low exposures
- » Symptoms range from mild to severe abdominal pain, diarrhea,

fever, malaise; lasting several days to several weeks

- » Vast majority of those with symptoms of gastroenteritis recover without treatment

- **Therapeutic Approaches & Considerations**

- » See patient's calprotectin level to determine GI inflammation
- » Consider high dose probiotics, broad-spectrum antimicrobial herbs, and 5R Protocol (*see Table 2*)
- » Heavy infections can be treated with azithromycin and fluoroquinolones

## ***Clostridium difficile*, Toxin A and Toxin B**

The GI-MAP tests only for the genes for toxin A and toxin B, which are carried by *C. difficile*. The GI-MAP does not measure toxins directly for any microbe.

- **Epidemiology**

- » 2–10% of population are carriers, most are asymptomatic
- » Prolonged use of antibiotics may be causative factor

- **Clinical Implications**

- » Symptoms include inflammation, abdominal pain, cramping, fever, and diarrhea
- » Symptoms often present during antibiotic use and often subside once antibiotics are discontinued
- » Gastrointestinal (GI) infection can cause reactive arthritis

- **Therapeutic Approaches & Considerations**

- » See patient's calprotectin and secretory IgA (SIgA) levels to determine GI inflammation and immune response.
- » Consider *Saccharomyces boulardii*, high dose probiotics, broad-spectrum antimicrobial herbs, and 5R Protocol (see Table 2)
- » Mild infections can be treated with metronidazole
- » Heavy infections can be treated with vancomycin and fidaxomicin
- » Asymptomatic patients may not need treatment

- » In asymptomatic patients with positive toxins A and/or B, the genes are likely not “turned on,” and thus not causing disease. It is still prudent to avoid antibiotics in these patients to prevent CDAD. Consider antimicrobial herbal formulas, which can suppress *C. diff* without activating toxin production.
- » Additional testing for toxins A and B may be warranted

## ***Enterohemorrhagic E. coli (EHEC)***

- **Epidemiology**

- » Fecal contamination of food (*undercooked beef, raw milk, and unpasteurized juice*) and water
- » Implicated in hemorrhagic colitis, may progress to hemolytic uremic syndrome (HUS)

- **Clinical Implications**

- » Symptoms include fever, abdominal cramping, fatigue, nausea, and diarrhea
- » Symptoms may last up to a week

- **Therapeutic Approaches & Considerations**

- » See patient's calprotectin and SIgA levels to determine GI inflammation and immune response.
- » Antibiotics may be contraindicated; they can initiate hemolytic uremic syndrome (HUS)
- » Consider high-dose probiotics (300+ billion CFU/g) such as: *Lactobacillus acidophilus*, *Bifidobacterium bifidum*, *Bifidobacterium longum*, *Lactobacillus rhamnosus*,

**Table 2.** Clinical Approach — *The Five “R” Treatment Protocol.*

The 5R Protocol is a widely accepted clinical guideline to treating pathogens and imbalances in the GI microbiota and restoring health to the gastrointestinal tract. Re-test patients with the GI-MAP in 3–6 months to monitor progress and make changes to the treatment protocol as needed.

<b>REMOVE</b> Using a course of antimicrobial, antiviral, antifungal, or antiparasitic therapies in cases where these organisms are present. It may also be necessary to remove offending foods, gluten, or medication that may be acting as antagonists.	<b>Antimicrobial</b>	Broad-spectrum antimicrobial herbs including: berberine, caprylic acid, garlic oil, oil of oregano, uva ursi, olive leaf extract
	<b>Antibiotics</b>	Research the recommended antibiotic for the specific microbe present. Avoid medications to which the microbe is thought to have resistance.
	<b>Antifungal</b>	Caprylic acid, garlic oil, oil of oregano, olive leaf extract
	<b>Antiparasitic</b>	Black walnut, garlic oil, oil of oregano, Artemisia (wormwood), berberine, goldenseal, gentian root extract, quassia bark extract, citrus seed extract
	<b>Antiviral</b>	Olive leaf extract, purified silver, cat’s claw, monolaurin, osha root ( <i>Ligusticum porteri</i> ), vitamin A, vitamin C, vitamin D, reishi mushrooms, <i>Echinacea</i> , zinc
<b>REPLACE</b> In cases of maldigestion or malabsorption, it may be necessary to restore proper digestion by supplementing with digestive enzymes.	<b>Digestive support</b>	Betaine hydrochloride, apple cider vinegar, herbal bitters, ox bile, lactase, pancreatic enzymes (amylase, lipase, protease), pepsin
<b>REINOCULATE</b> Recolonization with healthy, beneficial bacteria. Supplementation with probiotics, along with the use of prebiotics helps re-establish the proper microbial balance.	<b>Probiotics</b>	<i>Lactobacillus acidophilus</i> , <i>Bifidobacterium bifidum</i> , <i>Bifidobacterium longum</i> , <i>Lactobacillus rhamnosus</i> , <i>Bifidobacterium breve</i> , <i>Lactobacillus casei</i> , <i>Saccharomyces boulardii</i>
	<b>Prebiotics</b>	Beta-glucan, fiber, inulin, pectin, xylooligosaccharides, galactooligosaccharides, larch arabinogalactans
<b>REPAIR</b> Restore the integrity of the gut mucosa by giving support to healthy mucosal cells, as well as immune support.	<b>Immune Support</b>	Colostrum, immunoglobulins, <i>S. boulardii</i>
	<b>Intestinal Barrier Repair</b>	L-Glutamine, aloe vera extract, deglycyrrhized licorice, marshmallow root, okra, N-acetyl glucosamine, quercetin, <i>S. boulardii</i> , slippery elm, zinc carnosine, vitamin A, essential fatty acids, B vitamins
<b>REBALANCE</b> Address whole body health and lifestyle factors so as to prevent future GI dysfunction.	<b>Support Consideration</b>	Sleep, diet, exercise, and stress management

*Bifidobacterium breve*, *Lactobacillus casei*, *Streptococcus thermophilus*

- » Consider bacteriophages, broad-spectrum antimicrobial herbs, and 5R Protocol (see Table 2)

## ***E. coli* 0157**

### • Epidemiology

- » Fecal contamination of food and liquids (*dairy, undercooked beef, vegetables, juices*)
- » Implicated in many outbreaks and cases of bloody diarrhea and HUS
- » High prevalence worldwide

### • Clinical Implications

- » Symptoms may include severe abdominal cramps and diarrhea
- » Shiga toxins inhibit protein synthesis & elicit strong inflammatory response

### • Therapeutic Approaches & Considerations

- » See patient's calprotectin and SIgA levels to determine GI inflammation and immune response.
- » Antibiotics may be contraindicated; they can initiate HUS
- » Consider high-dose probiotics (300+ billion CFU/d)
- » Consider bacteriophages, broad-spectrum antimicrobial herbs, and 5R Protocol (see Table 2)

## **SOURCES OF EXPOSURE AND RE-INFECTION**

To effectively treat infections and prevent reinfection, exposure should be identified and eliminated. Most exposure to pathogens occurs via fecal-oral transmission, most often due to use of contaminated water sources or improper hand hygiene. This may include drinking contaminated water, eating raw foods washed in contaminated water or harvested (*e.g. shellfish*) in contaminated water, or improper handwashing.

To remove microorganisms from food, the FDA recommends first washing your hands, running cool water over fruits and vegetables, while rubbing or scrubbing, and then letting them dry out before eating. During treatment, consider all possible sources of fecal transmission: romantic partners, children (*especially if in diapers or not toilet-trained*), sheets, towels, water source to the home, etc...

### **Enteroinvasive *E. coli* / *Shigella***

- **Epidemiology**
  - » Fecal contamination of ingested foods
- **Clinical Implications**
  - » Symptoms include diarrhea (*with blood and/or mucus*), vomiting, fever, chills, fatigue, and abdominal cramping
  - » Symptoms are generally self-limiting
  - » Gastrointestinal (GI) infection can cause reactive arthritis
- **Therapeutic Approaches & Considerations**
  - » See patient's calprotectin and SIgA levels to determine GI inflammation and immune response.
  - » Antibiotics may be contraindicated; they can initiate HUS
  - » Consider high-dose probiotics (300+ billion CFU/d)
  - » Consider bacteriophages, broad-spectrum antimicrobial herbs, and 5R Protocol (*see Table 2*)

### **Enterotoxigenic *E. coli* LT/ST**

- **Epidemiology**
  - » Fecal contamination of ingested foods (*hamburger meat, unpasteurized milk, and contaminated water*)
- **Clinical Implications**
  - » Symptoms include watery, bloody diarrhea

- **Therapeutic Approaches & Considerations**
  - » See patient's calprotectin and SIgA levels to determine GI inflammation and immune response
  - » Antibiotics may be contraindicated; they can initiate HUS
  - » Consider high-dose probiotics (300+ billion CFU/d)
  - » Consider bacteriophages, broad-spectrum antimicrobial herbs, and 5R Protocol (*see Table 2*)

### **Shiga-like Toxin *E. coli* stx1**

- **Epidemiology**
  - » Most common cause of traveler's diarrhea
- **Clinical Implications**
  - » Diarrhea is the most common symptom
- **Therapeutic Approaches & Considerations**
  - » See patient's calprotectin and SIgA levels to determine GI inflammation and immune response
  - » Antibiotics may be contraindicated; they can initiate HUS
  - » Consider high-dose probiotics (300+ billion CFU/d)
  - » Consider bacteriophages, broad-spectrum antimicrobial herbs, and 5R Protocol (*see Table 2*)

### Shiga-like Toxin *E. coli* stx2

- **Epidemiology**
  - » Fecal contamination of ingested foods (*undercooked meat, unpasteurized milk, juice, and water*)
- **Clinical Implications**
  - » Symptoms may include severe abdominal cramps and diarrhea
  - » Toxins may elicit strong inflammatory response
- **Therapeutic Approaches & Considerations**
  - » See patient's calprotectin and SIgA levels to determine GI inflammation and immune response
  - » Antibiotics may be contraindicated; they can initiate HUS
  - » Consider high-dose probiotics (300+ billion CFU/d)
  - » Consider bacteriophages, broad-spectrum antimicrobial herbs, and 5R Protocol (*see Table 2*)
  - » Antibiotics and antidiarrheal medicines are contraindicated; they may increase the risk of developing HUS

- » Symptoms include fever, vomiting, and severe diarrhea
- » Typically self limiting within seven days
- » GI infection can cause reactive arthritis and may be involved in ankylosing spondylitis
- » Systemic infections may require treatment with antibiotics

- **Therapeutic Approaches & Considerations**

- » See patient's calprotectin and SIgA levels to determine GI inflammation and immune response
- » Remove sources of infection
- » Consider high-dose probiotics (300+ billion CFU/d)
- » Consider broad-spectrum antimicrobial herbs and 5R Protocol (*see Table 2*) Antibiotics are contraindicated; they may cause relapse of infection

### Salmonella

- **Epidemiology**
  - » Fecal contamination of ingested foods (*eggs, poultry, meat, unpasteurized milk, raw fruits, and vegetables*)
  - » Exposure to pets (*reptiles, amphibians, baby chicks*)
- **Clinical Implications**
  - » May be asymptomatic

**Table 3.**

FOOD SOURCES OF SALMONELLA
Poultry and poultry products
Meat
Dairy
Raw, fresh, ready-to-eat produce such as: <ul style="list-style-type: none"> <li>• Tomatoes</li> <li>• Leafy greens</li> <li>• Sprouts</li> <li>• Berries</li> <li>• Melons</li> </ul>

## ***Vibrio cholerae***

- **Epidemiology**
  - » Fecal contamination of ingested foods (*raw shellfish*) and often picked up during international travel
- **Clinical Implications**
  - » May be asymptomatic or cause mild symptoms
  - » Severe infections present with profuse watery diarrhea (*“rice-water stools”*), vomiting, rapid heart rate, loss of skin elasticity, thirst, dry mucous membranes, low blood pressure, restlessness, or irritability
- **Therapeutic Approaches & Considerations**
  - » See patient’s calprotectin and SIgA levels to determine GI inflammation and immune response.
  - » Rehydration therapy
  - » Zinc, especially in children
  - » Consider probiotics, broad-spectrum antimicrobial herbs and 5R Protocol (*see Table 2*)
  - » Heavy infections may be treated with doxycycline

## ***Yersinia enterocolitica***

- **Epidemiology**
  - » Fecal contamination of ingested foods and liquids (*water, undercooked pork, meats, and dairy products*)
- **Clinical Implications**
  - » Symptoms usually develop four to seven days after exposure and are self-limiting
  - » Symptoms include water or bloody diarrhea, fever, vomiting, and abdominal pain (*may resemble appendicitis*)
  - » Symptoms may mimic Crohn’s disease
  - » May trigger autoimmune thyroiditis or inflammatory arthritis in susceptible individuals
- **Therapeutic Approaches & Considerations**
  - » Consider probiotics, broad-spectrum antimicrobial herbs and 5R Protocol (*see Table 2*)
  - » Heavy infections can be treated with doxycycline in combination with an aminoglycoside
  - » Trimethoprim-sulfamethoxazole, chloramphenicol, and rifaximin may also be useful treatments

## PARASITIC PATHOGENS

### *Cryptosporidium*

#### Epidemiology

- » Fecal contamination of ingested foods and liquids (*contaminated water and swimming pools, undercooked meat, and raw milk*)
- » Common cause of traveler's diarrhea

#### • Clinical Implications

- » Symptoms typically last 2–3 weeks and are self-limiting
- » If symptoms persist, look for sources of contamination, such as drinking water
- » Can cause reactive arthritis

#### • Therapeutic Approaches & Considerations

- » May not require treatment
- » See patient's calprotectin and SIgA levels to determine GI inflammation and immune response
- » If necessary, consider anti-parasitic herbal treatments containing ingredients such as black walnut, garlic oil, oil of oregano, Artemisia (wormwood), berberine, goldenseal, gentian root extract, quassia bark extract, citrus seed extract
- » Consider probiotics and 5R Protocol (*see Table 2*)
- » Search for and remove sources of fecal contamination
- » Heavy infections can be treated with nitazoxanide\*

### *Entamoeba histolytica*

#### • Epidemiology

- » Fecal contamination of ingested foods or water
- » Pets may be a source of exposure
- » Sexual contact may be a source of exposure

#### • Clinical Implications

- » Symptoms include diarrhea, fulminating colitis (*resembling ulcerative colitis*), and dysentery
- » Extreme cases may invade liver and lung tissues

#### • Therapeutic Approaches & Considerations

- » See patient's calprotectin and SIgA levels to determine GI inflammation and immune response
- » Treatment may be indicated, even in asymptomatic carriers
- » Mild infections can be treated with Iodoquinol, paromomycin, or diloxanide furoate\*
- » Moderate to heavy infections can be treated with metronidazole or tinidazole, followed by iodoquinol or paromomycin\*
- » If appropriate, consider anti-parasitic herbal treatments (*see Table 2*)
- » Consider probiotics and 5R Protocol (*see Table 2*)
- » Avoid reinfection by fecal contamination

### Giardia

- **Epidemiology**

- » Most commonly isolated protozoan worldwide
- » Found in outside water sources (*lakes, streams, ponds*) and can get past filtration systems
- » Carried by animals
- » Common in daycare workers

- **Clinical Conditions**

- » May be asymptomatic, especially in patients with adequate levels of normal bacteria and SIgA
- » Symptoms include acute diarrhea, bloating, cramps, weight loss, intestinal malabsorption, and steatorrhea
- » Can cause urticaria or neurologic symptoms such as irritability, sleep disorder, or depression

- » May cause malnutrition and vitamin B12 deficiency
- » Can cause reactive arthritis

- **Therapeutic Approaches & Considerations**

- » See patient's calprotectin and SIgA levels to determine GI inflammation and immune response
- » Infections can be treated with tinidazole, nitazoxanide, metronidazole, paramomycin, furazolidone, or quinacrine\*
- » Consider probiotics and 5R Protocol (*see Table 2*) to repair and rebuild the gut mucosa

\* Additional information (dosing, efficacy, etc.) on pharmaceutical treatment for parasites may be found at [www.cdc.gov/parasites/index.html](http://www.cdc.gov/parasites/index.html) and in the Physician's Desk Reference.



*Giardia intestinalis* protozoan

## VIRAL PATHOGENS

### Adenovirus 40/41

- **Epidemiology**
  - » Common cause of diarrhea in infants and children but can also affect adults
  - » Mainly transmitted by fecal contamination (*fecal-oral route*)
- **Clinical Implications**
  - » Causative agents of gastrointestinal disease and gastroenteritis
  - » Symptoms include fever and watery diarrhea, usually limited to 1–2 weeks
  - » May also be present in the stool of asymptomatic carriers and may not require treatment
- **Treatment**
  - » Handwashing
  - » Hydration
  - » Antiviral herbs such as cat's claw, osha root, reishi mushrooms, vitamins A, C, and D, zinc, Echinacea
  - » Address other imbalances on the GI-MAP and use 5R Protocol (*see Table 2*) to rebuild gut health and gut immunity

### Norovirus GI/GII

- **Epidemiology**
  - » Fecal contamination of ingested foods and water
  - » Common cause of stomach flu on cruise ships
  - » Common cause of non-bacterial gastroenteritis and outbreaks in the world
- **Clinical Implications**
  - » Symptoms include nausea and vomiting, diarrhea, abdominal cramps, low-grade fever, muscle aches, fatigue, and headache
  - » Generally short-lived, lasting about 24–72 hours
- **Treatment**
  - » Antivirals are not recommended
  - » Supportive care for the gastric mucosa, hydration, and immune-boosting agents may be warranted
    - Handwashing
    - Hydration
    - Antiviral herbs such as cat's claw, osha root, reishi mushrooms, vitamins A, C, and D, zinc, Echinacea
    - Address other imbalances on the GI-MAP and use 5R Protocol (*see Table 2*) to rebuild gut health

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# | *H. pylori*

## AND VIRULENCE FACTORS

### ***Helicobacter pylori* (*H. pylori*)**

Recent studies have shown that nearly 50% of the world's population may harbor *H. pylori*. And, although many carriers are asymptomatic, *H. pylori* is known to have a causative role in ulcers, chronic gastritis, and stomach cancer. Additionally, in early phases of colonization, patients may experience hypochlorhydria followed by a change to hyper aciduria. Over time, additional *H. pylori* strains may colonize, including those with Virulence Factors and increased disease potential.

- **Epidemiology**

- » Fecal contamination, oral to oral, and family inter-infection are common modes of transmission

- **Clinical Implications**

- » Dyspepsia, abdominal pain, nausea, vomiting and chronic gastrointestinal symptoms
- » Peptic ulcers
- » May induce mucosal atrophy and metaplastic changes

### ***Virulence Factors***

Of the 50% of the population believed to be infected with *H. pylori*, only 2% develop gastric cancer. Positive *H. pylori* virulence factors on the GI-MAP represent the **genetic potential** for an *H. pylori* strain to cause pathology. For example, some clinicians may choose an aggressive treatment protocol for a patient with dyspepsia and a family history of gastrointestinal cancer, who shows elevated *H. pylori* and positive virulence factors. (See Table 4)

- **Treatment**

- » Asymptomatic patients may not require treatment
- » Consider herbal formulas to eradicate or suppress *H. pylori*. Ingredients may include: deglycyrrhized licorice, mastic gum, methylmethionine sulfonium chloride, vitamin C, zinc carnosine, bismuth citrate, berberine, goldenseal, oil of oregano, grape extract, Chinese goldthread extract, yerba mansa extract
- » See pancreatic elastase-1 to determine if maldigestion and/or hypochlorhydria might be present
- » Consider high-dose probiotics and 5R Protocol (see Table 2)

- » Rebuild healthy gastric mucosa by reducing stress and giving soothing and healing agents such as glutamine, aloe, DGL, and vitamin A
- » Address dental hygiene; the mouth is a reservoir for *H. pylori*
- » Consider sources of exposure, especially romantic partners or family members
- » Address other imbalances on the GI-MAP
- » For peptic ulcer disease, the first-line triple therapy (*prescription*) treatment includes a proton pump inhibitor, clarithromycin, and amoxicillin or metronidazole
- » Fluoroquinolones and tetracycline are used in second-line regimens against *H. pylori*
- » See the GI-MAP Antibiotic Resistance Genes results for *Helicobacter* when designing an antibiotic protocol

H. PYLORI ANTIBIOTIC RESISTANCE GENES		
	Result	Reference
Clarithromycin	Positive	Negative
Genes associated with clarithromycin resistance		
A2142C	Absent	
A2142G	Absent	
A2143G	Present	

**Figure 2.** An example antibiotic resistance gene measured on the GI-MAP for *H. pylori*. Number and letter combinations are single nucleotide polymorphisms (SNPs), or gene targets, that are involved in *H. pylori* drug resistance. If any SNP is detected (*present*), then the *H. pylori* strain/s are resistant to that class of antibiotics. In this example, the patient's *H. pylori* is resistant to the clarithromycin class of antibiotics and it would be prudent to use a different antibiotic when tailoring a treatment protocol.

*Note: In supporting individuals with H. pylori, consider the patient history, clinical symptoms, virulence genes, and the amount of H.pylori DNA detected in order to design a customized treatment plan.*



*Helicobacter pylori* bacterium

**Table 4.** *H. pylori* virulence factors and disease associations.

## *Helicobacter pylori* Virulence Factors

### Quick Reference Guide

The virulence factor genes on GI-MAP® are found exclusively on the genome of *H. pylori*.

These genes code for proteins that will predispose one to more serious *H. pylori* infections.

The chart below provides details of each virulence factors tested on the GI-MAP.

Gene Acronym	Gene Name	Genetic Characteristics	Associations with Disease
<b>BabA</b>	Blood Group Antigen Binding Adhesion	<ul style="list-style-type: none"> <li>Promotes DNA breakage in host cell</li> <li>Improves <i>H. pylori</i> adherence (“stickiness”) to epithelial cells</li> <li>May promote other virulence factors, especially CagA</li> </ul>	May promote carcinogenesis
<b>CagA</b>	Cytotoxin Associated Gene A	<ul style="list-style-type: none"> <li>Promotes <i>H. pylori</i> adhesion and colonization</li> <li>Affects barrier function of gastric epithelial tight junctions</li> <li>Promotes loss of cell polarity</li> <li>Antagonizes VacA</li> <li>Evades the immune system and affects the activity of dendritic cells and B-cells.</li> <li>Considered part of the “pathogenicity island” which includes VirB and VirD virulence factors. This is a closely-associated group of genes that work synergistically and often transfer as a unit.</li> </ul>	Promotes carcinogenesis, strong association. Also associated with peptic ulcer disease
<b>DupA</b>	Duodenal Ulcer-Promoting Gene A	<ul style="list-style-type: none"> <li>Promotes inflammation</li> </ul>	Associated with duodenal ulcers, specifically
<b>IceA</b>	Induced by Contact with Epithelium A	<ul style="list-style-type: none"> <li>Transcription of this gene is only initiated after adhesion to the gastric epithelium</li> <li>Promotes inflammation and associated with elevated IL-8</li> </ul>	Associated with dyspepsia and gastric & duodenal ulcers  NOT associated with gastric cancer
<b>OipA</b>	Outer Inflammatory Protein A	<ul style="list-style-type: none"> <li>Promotes inflammation</li> <li>Drives IL-8 production</li> </ul>	Associated with carcinogenesis and peptic ulcer disease
<b>VacA</b>	Vacuolating Toxin A	<ul style="list-style-type: none"> <li>Enters the host cell by endocytosis</li> <li>Affects mitochondrial function</li> <li>Disrupts tight junctions</li> <li>Causes a programmed necrosis by inducing the production of large vacuoles inside the host cells; inducing cellular swelling; disrupting cell barrier thus causing nutrient leakage</li> <li>Facilitates nutrient acquisition (iron, minerals, amino acids, etc.)</li> <li>Inhibits antigen presentation in vitro</li> <li>Antagonizes CagA</li> </ul>	Associated with gastric inflammation, peptic ulcer disease, and gastric cancers
<b>VirB &amp; VirD</b>		<ul style="list-style-type: none"> <li>Part of the CagA “pathogenicity island”</li> <li>Both genes can potentiate CagA virulence factor by aiding in its transmission to host epithelial cells</li> <li>In the absence of CagA, these virulence factors are unlikely to change clinical outcome of <i>H. pylori</i> infections.</li> </ul>	Evaluate next to CagA virulence factors. VirB & VirD, if positive, can potentiate CagA virulence and clinical associations

- **How To Target Treatments in the Presence of Virulence Factors:**

» Generally, when virulence factors are present, the treatment goal will be to fully eradicate the *H. pylori* population. This can be confirmed by retesting the full GI-MAP, the pathogen panel, or the *H. Pylori* panel 4–6 weeks after completing treatment. The goal is to achieve a result of <dl on the retest. The exception to this may be

VirB and VirD if they are found in isolation (without CagA present).

» Below is a chart of treatment considerations for each of the virulence factors. These would be used in addition to the standard treatments for *H. pylori* alone.

**Table 4a.** *H. pylori* virulence factors and treatment considerations.

Virulence Factor	Special Treatment Considerations
<b>BabA</b>	More aggressive treatment may be warranted; consider the use of adhesion inhibitions, particularly cranberry
<b>CagA</b>	Target inflammatory support, promote T-cell activity, consider curcumin, resveratrol/red wine, ginger, Nigella sativa, low salt diet
<b>DupA</b>	Consider the use of demulcents for mucosal protection
<b>IceA</b>	Inflammatory support, consider the use of adhesion inhibitors
<b>OipA</b>	Inflammatory support
<b>VacA</b>	Mitochondrial support, consider Nigella sativa, green tea, red wine/resveratrol, Scutellaria baicalensis
<b>VirB &amp; VirD</b>	No additional treatments necessary

*Please see the GI-MAP white paper for additional, fully referenced, information.*



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# | COMMENSAL/ KEYSTONE BACTERIA

Trillions of microorganisms inhabit the human intestine to make up a complex ecosystem that plays an important role in human health. Commensal bacteria extract nutrients and energy from our diets, maintain gut barrier function, produce vitamins (*biotin and vitamin K*), and protect against colonization by potential pathogens.



*Bacteria Lactobacillus, lactic acid bacteria which are part of normal flora of human intestine*

## THE FOLLOWING COMMENSAL/KEYSTONE BACTERIA ARE REPORTED ON THE GI-MAP

Table 5.

COMMENSAL BACTERIA	
<b><i>Bacteroides fragilis</i></b>	Gram-negative species of the <i>Bacteroidetes</i> phylum. Immune-modulating normal gut species. Believed to be involved in microbial balance, barrier integrity, and neuroimmune health (Hsiao 2013). High levels may result from reduced digestive capacity or constipation. Low levels may contribute to reduced anti-inflammatory activity in the intestine.
<b><i>Bifidobacterium</i> spp.</b>	Gram-positive genus in the <i>Actinobacteria</i> phylum. Present in breast milk. Colonizes the human GI tract at birth. Common in probiotics. Thrives on a wide variety of prebiotic fibers. Low levels may result from low fiber intake or reduced mucosal health. High levels are more common in children than in adults.
<b><i>Enterococcus</i> spp.</b>	Gram-positive genus of lactate-producing bacteria in the <i>Firmicutes</i> phylum. High levels may be due to reduced digestive capacity, constipation or small intestinal bacterial overgrowth. Low levels may indicate insufficiency of beneficial bacteria.
<b><i>Escherichia</i> spp.</b>	Gram-negative genus in the <i>Proteobacteria</i> phylum. Normal gut flora. <i>Escherichia coli</i> ( <i>E. coli</i> ) is the primary species in this genus. Most <i>E. coli</i> are nonpathogenic ( <i>pathogenic E. coli</i> strains are measured separately in "Pathogens" section of the GI-MAP). High levels may be indicative of increased intestinal inflammatory activity. Low levels may indicate reduced mucosal health and decreased protection against pathogenic <i>E. coli</i> .
<b><i>Lactobacillus</i> spp.</b>	Gram-positive genus of lactate-producing bacteria in the <i>Firmicutes</i> phylum. Many strains used as probiotics. High levels may result from reduced digestive capacity or excessive intake of carbohydrates. Low levels may be due to low carbohydrate intake or high salt intake, and may also indicate reduced mucosal health.
<b><i>Enterobacter</i> spp.</b>	Gram-negative genus in the <i>Proteobacteria</i> phylum. Closely related to <i>E. coli</i> ( <i>in the same taxonomic family</i> ). High levels may indicate increased intestinal inflammatory activity. Low levels may indicate reduced mucosal health.
<b><i>Akkermansia muciniphila</i></b>	Keystone species and primary mucus degrader. Generates mucus-derived sugars and metabolic products that support the growth and energy needs of other gut microbes. Promotes mucosal health and mucus production. Low levels associated with obesity and metabolic dysfunction. High levels linked to multiple sclerosis.
<b><i>Faecalibacterium prausnitzii</i></b>	Widely recognized as an important keystone species in the Clostridia class, as well as a major butyrate producer. Promotes anti-inflammatory processes and mucosal homeostasis. Reduced levels have been associated with a wide range of chronic inflammatory and autoimmune diseases.
<b><i>Roseburia</i> spp.</b>	A genus of Gram-positive anaerobic bacteria in the <i>Clostridia</i> class that inhabit the human colon. The <i>Roseburia</i> genus has five well-characterized species, all of which produce short-chain fatty acids (SCFAs), such as acetate, propionate, and butyrate. <i>Roseburia</i> can also produce butyrate from acetate promoting balance in energy homeostasis. The genus is widely recognized to influence colonic motility, support immunity, and suppress inflammation. Low levels are associated with several disease (including irritable bowel syndrome, obesity, Type 2 diabetes, nervous system conditions and allergies).

- **Therapeutic Options for Abnormally Low Commensal Bacterial Findings**
  - » Use a broad-spectrum, diverse probiotic formula, 50–450 billion CFUs/day depending on findings. May contain: *Lactobacillus acidophilus*, *Bifidobacterium bifidum*, *Bifidobacterium longum*, *Lactobacillus rhamnosus*, *Bifidobacterium breve*, *Lactobacillus casei*, *Streptococcus thermophilus*.
  - » Increase dietary intake of vegetables and fibers (*psyllium*, *oat bran*)
  - » Remove dietary sugar and refined carbohydrates
  - » Prebiotic supplementation (*resistant starch*, *xylooligosaccharide*, *inulin*, *beta-glucan*, *arabinogalactan*)
  - » Fermented foods, if tolerated
  - » Reduce inflammation and address other imbalances on the GI-MAP
- **Therapeutic Options for Abnormally High Commensal Bacterial Findings**
  - » Consider any additional findings on GI-MAP and treat accordingly
  - » Re-establish commensal bacteria using 5R protocol (*see Table 2*)
  - » Remove dietary sugar and refined carbohydrates
  - » In certain situations, overgrowth of commensal bacteria may be treated judiciously with antimicrobial herbs when all other findings are normal.

## FIRMICUTES AND BACTEROIDETES PHyla

Gram-negative *Bacteroidetes* and gram-positive *Firmicutes* are bacterial phyla that dominate the entire human digestive tract, including the mouth, nose, throat, and colon. An abnormal result in one or both of these phylum suggest imbalanced normal microbes in the GI tract. Further, high *Firmicutes* and low *Bacteroidetes* (*resulting in a high F/B ratio*) suggest microbial imbalance which may be related to increased caloric extraction from food, fat deposition and lipogenesis, impaired insulin sensitivity, and increased inflammation.

### High Firmicutes/Bacteroidetes Ratio

- **Causes:**
  - » Poor diet
  - » Dysbiosis
  - » Maldigestion or hypochlorhydria
- **Therapeutic Approaches & Considerations**
  - » Balance commensal bacteria using the 5R Protocol (*see Table 2*)
  - » When *Firmicutes* phyla is high, consider using *Bifidobacteria* probiotics and *Saccharomyces boulardii* primarily.
  - » *Lactobacillus* spp. and *Bacillus* spp. (*found in probiotics*) can elevate *Firmicutes*
  - » Optimize the diet; a lower fat diet may help to normalize the F/B ratio
  - » Address all other imbalances on the GI-MAP

# | OPPORTUNISTIC BACTERIA

Many bacteria measured on the GI-MAP are considered opportunistic pathogens, as they only cause disease and illness in some individuals, particularly the immune-compromised. Many individuals come into contact with opportunistic bacteria and experience no symptoms. Most sources consider these microbes to be normal in the stool. However, they can cause gastroenteritis and inflammation at high levels in vulnerable patients. Symptoms may include diarrhea, loose stools, abdominal pain, or even constipation. Overgrowth and excessive colonization by opportunistic bacteria may occur when the commensal bacteria are impaired by poor diet, antibiotic use, parasitic infection, or a weakened immune system. When intestinal permeability is present (*see zonulin*), these microbes could escape the lumen of the gut and infect extraintestinal sites.

## OPPORTUNISTIC/OVERGROWTH MICROBES

Table 6.

DYSBIOTIC & OVERGROWTH BACTERIA	
<b><i>Bacillus</i> spp.</b>	Common group of gram-positive bacteria in the <i>Firmicutes</i> phylum. Some strains are used as probiotics. High levels may result from reduced digestive function, SIBO, or constipation.
<b><i>Enterococcus faecalis</i> <i>Enterococcus faecium</i></b>	Gram-positive species in the <i>Firmicutes</i> phylum. High levels may result from reduced stomach acid, PPI use, compromised digestive function, SIBO or constipation. High natural resistance to some antibiotics, which may result in overgrowth.
<b><i>Morganella</i> spp.</b>	Gram-negative group in the <i>Proteobacteria</i> phylum. May produce histamine. High levels may indicate increased intestinal inflammatory activity. High levels may cause diarrhea, and may also be associated with SIBO.
<b><i>Pseudomonas</i> spp. <i>Pseudomonas aeruginosa</i></b>	Gram-negative bacteria in the <i>Proteobacteria</i> phylum. High levels may indicate increased intestinal inflammatory activity and may cause abdominal cramping and loose stools. Some strains of <i>P. aeruginosa</i> may produce toxins that can damage cells.
<b><i>Staphylococcus</i> spp. <i>Staphylococcus aureus</i></b>	Gram-positive bacteria in the <i>Firmicutes</i> phylum. High levels may result from reduced digestive capacity, and intestinal inflammatory activity. Some strains may produce toxins and contribute to loose stools or diarrhea.
<b><i>Streptococcus</i> spp.</b>	Gram-positive bacteria in the <i>Firmicutes</i> phylum. <i>Streptococcus</i> spp. colonize skin and mucous membranes throughout the body; High levels in the intestine may result from low stomach acid, PPI use, reduced digestive capacity, SIBO or constipation; Elevated levels may also be indicative of intestinal inflammatory activity, and may cause loose stools.
COMMENSAL & OVERGROWTH MICROBES	
<b><i>Desulfovibrio</i> spp.</b>	A genus of Gram-negative sulfate reducing bacteria. The bacteria produce hydrogen sulfide (H <sub>2</sub> S), a metabolite which can influence cell signaling and reduce oxidative stress at low concentrations and pose toxicity at higher concentrations.
<b><i>Methanobacteriaceae</i> (family)</b>	Family of bacteria-like microbes that produce methane. Facilitates carbohydrate fermentation and short-chain fatty acid production by beneficial bacteria. High levels linked to chronic constipation, as well as some types of SIBO and IBS. Low levels may indicate reduced production of short-chain fatty acids and may be associated with inflammation.
INFLAMMATORY & AUTOIMMUNE-RELATED BACTERIA	
<b><i>Citrobacter</i> spp. <i>Citrobacter freundii</i></b>	Gram-negative bacteria in the <i>Proteobacteria</i> phylum. High levels may indicate increased intestinal inflammatory activity.
<b><i>Klebsiella</i> spp. <i>Klebsiella pneumoniae</i></b>	Gram-negative bacteria in the <i>Proteobacteria</i> phylum. Common residents of the oral cavity and respiratory tract. May cause diarrhea, gas, abdominal pain, and bloating; Common after long-term antibiotic use; May release histamine in the gut; High levels may indicate increased intestinal inflammatory activity.
<b><i>Mycobacterium avium</i> subsp. <i>paratuberculosis</i></b>	Bacterial species in the <i>Actinobacteria</i> phylum. Higher levels have been associated with Crohn's disease and rheumatoid arthritis.
<b><i>Proteus</i> spp. <i>Proteus mirabilis</i></b>	Gram-negative bacteria in the <i>Proteobacteria</i> phylum. High levels may indicate increased intestinal inflammatory activity; May contribute to loose stools or diarrhea; Pets or wild animals can be a source.

Table 6a.

COMMENSAL INFLAMMATORY & AUTOIMMUNE-RELATED BACTERIA	
<b><i>Enterobacter</i> spp.</b>	Gram-negative genus in the <i>Proteobacteria</i> phylum. Closely related to <i>E. coli</i> (in the same taxonomic family). High levels may indicate increased intestinal inflammatory activity. Low levels may indicate reduced mucosal health.
<b><i>Escherichia</i> spp.</b>	Gram-negative genus in the <i>Proteobacteria</i> phylum. Normal gut flora. <i>Escherichia coli</i> ( <i>E. coli</i> ) is the primary species in this genus. Most <i>E. coli</i> are nonpathogenic (pathogenic <i>E. coli</i> strains are measured separately in "Pathogens" section of the GI-MAP). High levels may be indicative of increased intestinal inflammatory activity. Low levels may indicate reduced mucosal health and decreased protection against pathogenic <i>E. coli</i> .
<b><i>Fusobacterium</i> spp.</b>	Genus of gram-negative bacteria in the <i>Fusobacteria</i> phylum. Commonly found in the oral cavity, and may also be found in the intestine. Associated with inflammatory processes, as well as autoimmune conditions such as systemic sclerosis.
<b><i>Prevotella</i> spp.</b>	Gram-negative species in the <i>Bacteroidetes</i> phylum. Associated with rheumatoid arthritis. High levels may result from reduced digestive capacity, or a high-starch diet.

- **Therapeutic Options and Considerations for Abnormally High Levels of Opportunistic Bacteria**
  - » Consider high-dose probiotics (300+ billion CFU/d)
  - » Consider broad-spectrum antimicrobial herbs including: berberine, caprylic acid, garlic oil, oil of oregano, uva ursi, or olive leaf extract
  - » Optimize diet (*low sugar, low refined carbs, high plant-based foods and fiber*)
  - » See SIgA level to determine mucosal immunity and if patient is protected from overgrowth symptoms
  - » Use the 5R Protocol (see Table 2)
  - » Identify and remove potential sources of contamination or re-infection
  - » Address all other imbalances on the GI-MAP

- » If using antibiotics, see the Physician's Desk Reference for appropriate antibiotics for the specific microorganisms that are overgrown
- » If using antibiotics, consider rifaximin, which remains in the GI tract and is also used to treat small intestinal bacterial overgrowth (SIBO)

*Bacillus cereus*

## OPPORTUNISTIC BACTERIA

- **Opportunistic Bacteria as a Trigger for Autoimmunity**

» Certain opportunistic bacteria may initiate autoimmune thyroiditis or inflammatory arthritis such as rheumatoid arthritis and ankylosing spondylitis. These bacteria may trigger

or sustain the autoimmune process. Gastrointestinal symptoms are less common when these bacteria are elevated. When intestinal permeability is present (*see zonulin*), these microbes could escape the lumen of the gut and infect extraintestinal sites.

**Table 7.** Opportunistic Bacteria and Viruses Associated with Autoimmunity.

OPPORTUNISTIC BACTERIA AND AUTOIMMUNE ASSOCIATION	
<i>Citrobacter</i> spp.	Rheumatoid arthritis
<i>Fusobacterium</i> spp.	Systemic sclerosis or inflammatory bowel disease
<i>Klebsiella</i> spp.	Crohn's disease, ulcerative colitis, ankylosing spondylitis, and other spondyloarthropathies ( <i>which include ankylosing spondylitis, arthritis associated with Crohn's or ulcerative colitis, psoriatic arthritis, and reactive arthritis</i> )
<i>M. avium</i> subsp. <i>paratuberculosis</i>	Rheumatoid arthritis, Crohn's disease, Type I diabetes, possibly psoriasis
<i>Prevotella copri</i>	Rheumatoid arthritis
<i>Proteus</i> spp.	Rheumatoid arthritis
<i>Proteus mirabilis</i>	Rheumatoid arthritis and spondyloarthropathies ( <i>listed above</i> )

VIRUSES AND AUTOIMMUNE ASSOCIATION	
Cytomegalovirus (CMV)	Systemic lupus erythematosus, systemic sclerosis, type 1 diabetes, rheumatoid arthritis
Epstein Barr Virus (EBV)	Rheumatoid arthritis, lupus, Sjogren's, multiple sclerosis, autoimmune thyroid disorders

# | FUNGI/YEAST

Fungal organisms are commonly found in the human digestive tract, but fungal overgrowth can cause illness in susceptible individuals. Fungal growth may be localized in the body. For instance, *Candida* spp. may be high in the large intestine but normal in the small intestine, and vice versa. In a patient with suspected fungal overgrowth, additional tests may be necessary to understand the complete picture of fungal overgrowth. Urinary D-arabinitol or antibodies to *Candida* are sometimes used.

- **Common Causes of Yeast Overgrowth Include:**

- » Antibiotic use
- » High intake of sugar, starches, and dietary fungi (*beer, bread, nuts, cheese, corn*)
- » Hypochlorhydria
- » Impaired immune function
- » Dysbiosis

- **Fungi/Yeast Targeted on the GI-MAP**

- » *Candida albicans* and *Candida* spp.
  - Commensal fungi that can be pathogenic to immunocompromised patients. Causes vaginal yeast infections and can be fatal in systemic infections. May cause diarrhea.

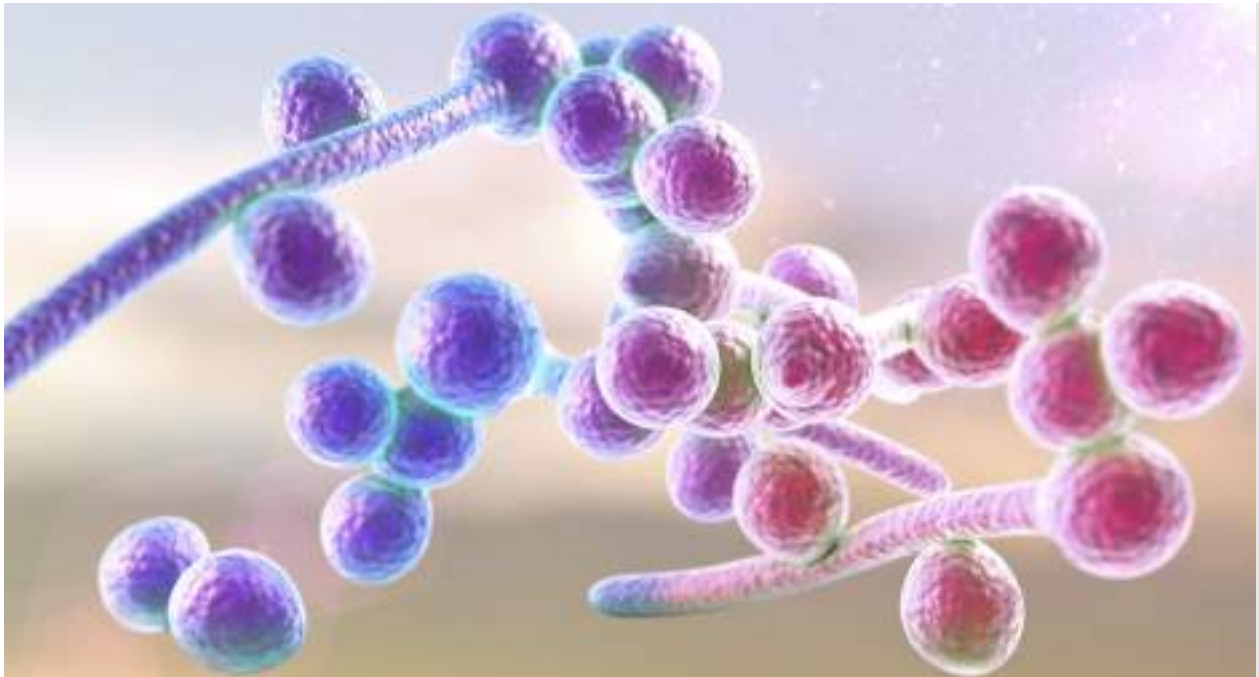
Has been suggested to cause a cluster of symptoms including GI complaints, fatigue, and muscle or joint pain but evidence is weak.

- » *Geotrichum* spp.

- May cause disease in immunosuppressed patients. Low levels may be a dietary artefact; certain strains are used to make soft cheeses.

- » *Microsporidia* spp.

- The GI-MAP specifically detects *Encephalitozoon intestinalis*, which affects the GI. May cause diarrhea and wasting. Can disseminate to ocular, genitourinary, and respiratory tracts.



*Candida albicans*

- » *Rhodotorula* spp.
  - Common in soil, plants, bathrooms, and in beverages like milk, juice, and water. May be a commensal. Can cause disease in immunosuppressed patients.
- **Common Symptoms of Fungal Dysbiosis**
  - » GI symptoms: Gas, bloating, constipation, nausea, vomiting, and diarrhea.
  - » Other symptoms: Eczema, athlete's foot, vaginal yeast infections, thrush, and jock itch.
- **Therapeutic Options and Considerations for Abnormally High Levels of Fungi/Yeast**
  - » Reduce intake of sugars, starches, and fungi
  - » See SIgA levels and consider immune support
  - » Consider high-dose probiotics, *Saccharomyces boulardii*, and the 5R Protocol (see Table 2)
  - » Consider antifungal herbs such as caprylic acid, undecylenic acid, oregano oil, berberine, and/or garlic
  - » Consider pharmaceutical antifungals in severe cases. Nystatin is preferred because it stays in the GI tract.

# VIRUSES

## Cytomegalovirus

- **Epidemiology**

- » Herpes virus that has infected 60% of the US population
- » One in three children have contracted CMV by five years old
- » Passed around in child daycare centers

- **Clinical Implications**

- » Positive CMV on the GI-MAP indicates active infection of the GI, NOT past infection
- » Active infection may be asymptomatic or cause mild flu-like symptoms
- » CMV can also cause viral pneumonia, transaminitis, splenomegaly, colitis, fever, and encephalitis
- » Common in inflammatory bowel disease, immunocompromised patients
- » CMV colitis has a similar presentation to *Clostridium difficile* infection
- » CMV has been implicated in autoimmune diseases: lupus, systemic sclerosis, type 1 diabetes, and rheumatoid arthritis



*Cytomegalovirus is a viral genus of the viral family known as Herpesviridae*

- **Therapeutic Options and Considerations**

- » No treatment is needed if asymptomatic
- » Prevent spreading CMV with regular handwashing
- » Antiviral herbs such as cat's claw, osha root, reishi mushrooms, vitamins A, C, and D, zinc, Echinacea
- » Address other imbalances on the GI-MAP and use 5R Protocol (see Table 2) to rebuild gut health and gut immunity

### Epstein Barr Virus

- **Epidemiology**
  - » One of the most common viruses worldwide; infects 90–95% of the population
  - » Commonly contracted in childhood and causes mild symptoms
- **Clinical Implications**
  - » Positive finding on the GI-MAP indicates active EBV infection of the GI, not past infections
  - » Can cause infectious mononucleosis (mono)
  - » Symptoms include fatigue, fever, swollen lymph nodes, inflamed throat, enlarged spleen, and more
  - » May last two to four weeks in adolescents and adults
  - » May cause fatigue for weeks or months
  - » Associated with autoimmune conditions such as rheumatoid arthritis, lupus, Sjogren's, multiple sclerosis, autoimmune thyroid disorders
- **Therapeutic Options and Considerations**
  - » Rest and hydration
  - » Antiviral herbs such as cat's claw, osha root; antiviral fungi such as reishi and/or Cordyceps mushrooms
  - » Vitamins A, C, and D, zinc, Echinacea
  - » Address other imbalances on the GI-MAP and use 5R Protocol (*see Table 2*) to rebuild gut health and gut immunity
  - » Follow-up blood testing may be indicated, including an EBV Early Antigen and EBV PCR test
- » EBV may increase the risk of gastric cancer; especially if *H. pylori* present
- » May cause colitis
- » Found in 30–64% of IBD patients

# | PARASITES

A parasite is an organism that lives and feeds on a host organism at the expense of the host. The GI-MAP tests for pathogenic parasites and protozoa (*some of which are non-pathogenic*) most commonly occurring in the GI tract. Sources of exposure should be identified and eliminated to prevent reinfection.

## PROTOZOA

### *Blastocystis hominis*

- **Epidemiology**
  - » Fecal contamination of food or water is common
  - » Found worldwide
- **Clinical Implications**
  - » Symptoms include diarrhea, abdominal pain, nausea and vomiting, fever, fatigue, irritable bowel syndrome, infective arthritis
- **Therapeutic options and considerations**
  - » Difficult to eradicate
  - » Consider nitazoxanide or tinidazole, oregano oil, and *S. boulardii*
  - » Herbal treatments may not be as effective
  - » Consider *Artemisia*, *Coptis*, or other broad-spectrum anti-parasitic herbal formulas
  - » Infection can be treated with metronidazole, iodoquinol or trimethoprim/sulfamethoxazole\*
  - » Consider probiotics and 5R Protocol (*see Table 2*)

### *Chilomastix mesnili*

- **Epidemiology**
  - » Fecal contamination of food or water
- **Clinical Implications**
  - » Considered non-pathogenic and may not cause symptoms
  - » May indicate dysbiosis or suppressed immunity
- **Therapeutic Options and Considerations**
  - » Look for and address sources of fecal-oral contamination
  - » Consider probiotics and 5R Protocol (*see Table 2*)
  - » Address other imbalances on the GI-MAP



*Cyclospora*

- » Can cause bloating, flatulence, and burping
- » Flu-like symptoms such as fatigue, headaches, and low fever may be present in some individuals
- » Infection is usually self-limiting, with symptoms usually lasting about seven days, but can last weeks or months in immunosuppressed patients

### *Cyclospora* spp. (*Cyclospora cayetanensis*)

- **Epidemiology**
  - » Fecal contamination of food and water
  - » Associated with water- and food-borne outbreaks
  - » Common cause of traveller's diarrhea
  - » May be found on imported fresh produce from tropical regions
- **Clinical Implications**
  - » Symptoms include prolonged watery diarrhea, abdominal cramping, loss of appetite, weight loss, nausea, and vomiting
  - » May cause alternating diarrhea and constipation

- **Therapeutic Options and Considerations**
  - » In cases lasting more than seven days, treatment with an antibiotic combination of trimethoprim and sulfamethoxazole may be necessary\*
  - » Consider probiotics, broad-spectrum anti-parasitic herbal formula, and the 5R Protocol (*see Table 2*)
  - » Look for and address sources of reinfection

### *Dientamoeba fragilis*

- **Epidemiology**
  - » Not well understood; probably fecal contamination of food or water

- **Clinical Implications**
  - » May be asymptomatic
  - » May cause diarrhea, abdominal pain, nausea, fever, fatigue, weight loss, appetite loss, and/or fatigue
- **Therapeutic Options and Considerations**
  - » “Moderate” amounts of DNA, that are not above the laboratory reference range, may cause symptoms and warrant treatment
  - » Infection can be treated with iodoquinol, paromomycin, or metronidazole\*
  - » Consider probiotics, broad-spectrum anti-parasitic herbal formula, and the 5R Protocol (*see Table 2*)
  - » Look for and address sources of reinfection
  - » Address other imbalances on the GI-MAP

### ***Endolimax nana***

- **Epidemiology**
  - » Fecal contamination of food or water
- **Clinical Implications**
  - » Considered non-pathogenic; individuals may be asymptomatic
  - » May be indicative of dysbiosis, conservative treatment may be indicated if clinical presentation is consistent with enteroparasitosis
- **Therapeutic Options and Considerations**
  - » Consider probiotics and the 5R Protocol (*see Table 2*)

- » Look for and address sources of fecal contamination
- » Address other imbalances on the GI-MAP

### ***Entameoba coli***

- **Epidemiology**
  - » Fecal contamination of food or water
  - » Found in the large intestine, considered to be non-pathogenic
- **Clinical Implications**
  - » May be indicative of dysbiosis, conservative treatment may be indicated if clinical presentation is consistent with enteroparasitosis
- **Therapeutic Options and Considerations**
  - » Consider probiotics and the 5R Protocol (*see Table 2*)
  - » Look for and address sources of fecal contamination
  - » Address other imbalances on the GI-MAP

### ***Pentatrichomonas hominis***

- **Epidemiology**
  - » Fecal contamination of food or water
- **Clinical Implications**
  - » Considered harmless, a non-pathogen
  - » Infected individuals are usually asymptomatic
  - » May contribute to dysbiosis
  - » Also colonizes dogs, cats, and other animals

- **Therapeutic Options and Considerations**

- » May be asymptomatic
- » In women with vaginosis, consider treatment to reduce chances of vaginal contamination or reinfection (*find treatments for Trichomonas vaginalis elsewhere*)
- » If treatment is needed, consider a broad-spectrum anti-parasitic herbal formula
- » Consider probiotics and the 5R Protocol (*see Table 2*)
- » Look for and address sources of fecal contamination
- » Address other imbalances on the GI-MAP

- **Clinical Implications**

- » Early symptoms are itching and rash where the larvae penetrated the skin
- » Symptoms of heavy infestations include: abdominal pain, diarrhea, fatigue, weight loss, iron deficiency anemia (IDA), coughing, and loss of appetite
- » Infected individuals may also be asymptomatic

- **Therapeutic Options and Considerations**

- » Heavy infections can be treated with albendazole or mebendazole\*
- » Individuals presenting with IDA may need iron supplementation
- » Consider anti-parasitic herbal treatments, gut immunity support, and the 5R Protocol (*see Table 2*)
- » Look for and remove sources of reinfection

## WORMS

### *Ancylostoma duodenale* and *Necatur americanus* (Hookworms)

- **Epidemiology**

- » Infection occurs via skin contact with soil contaminated with larvae or ingestion of larvae
- » Infected cats and dogs are a source of exposure
- » Prevalent in southern Europe, Northern Africa, India, Asia, Caribbean islands, South America, and small areas of the United States
- » Associated with poor sanitation, inadequate housing construction, and lack of access to medications

### *Ascaris lumbricoides* (Roundworm)

- **Epidemiology**

- » Fecal contamination of food or water
- » Common in international travellers and recent immigrants from Latin America and Asia

- **Clinical Implications**

- » Early symptoms include fever, coughing, wheezing, and dyspnea
- » Late symptoms include abdominal pain, nausea, vomiting, frequent throat clearing, dry cough, "tingling throat," appendicitis, pancreatitis, and obstruction

» Can cause reactive arthritis

- **Therapeutic Options and Considerations**

- » Infections may be treated with albendazole, mebendazole, or ivermectin\*
- » Consider anti-parasitic herbal treatments, gut immunity support, and the 5R Protocol (*see Table 2*)
- » Look for and remove sources of reinfection

### ***Trichuris trichiura* (Whipworm)**

- **Epidemiology**

- » Fecal contamination of produce or person-to-person contact
- » Prevalent in Asia, Africa, South America, and rural southeastern United States

- **Clinical Implications**

- » Most individuals are asymptomatic, however diarrhea with mucus and blood may occur in some infected individuals

- **Therapeutic Options and Considerations**

- » Infections may be treated with albendazole, mebendazole, or ivermectin\*
- » Individuals presenting with IDA may need iron supplementation



*Microscopic cross section of a whipworm (Trichuris trichiura)*

- » Consider anti-parasitic herbal treatments, gut immunity support, and the 5R Protocol (*see Table 2*)
- » Look for and remove sources of reinfection

### ***Taenia* spp. (Tapeworm)**

- **Epidemiology**

- » Fecal contamination of undercooked pork (*T. solium*) or beef (*T. saginata*)
- » *T. solium* is found worldwide, but prevalent in communities who raise and eat pigs
- » *T. saginata* is prevalent in Africa, parts of Eastern Europe, the Philippines, and Latin America where people raise cattle and eat raw beef

- **Clinical Implications**

- » May be asymptomatic or present with mild symptoms
- » Symptoms include abdominal pain, nausea, weakness, increased appetite, loss of appetite, headache, constipation, dizziness, diarrhea, pruritus ani, hyperexcitability, and anemia

- **Therapeutic Options and Considerations**

- » Infections may be treated with albendazole or praziquantel\*
- » Consider anti-parasitic herbal treatments, gut immunity support, and the 5R Protocol (*see Table 2*)
- » Look for and remove sources of reinfection

# | INTESTINAL HEALTH MARKERS

## DIGESTION

### Pancreatic Elastase 1

Elastase 1 is a digestive enzyme secreted exclusively by the pancreas, giving a direct indication of pancreatic function. Elastase 1 is unaffected by pancreatic enzyme replacement therapy.

- **Causes of Low Elastase 1:**
  - » Suppressed pancreatic function
  - » Gallstones
  - » Hypochlorhydria, especially if *H. pylori* present
  - » Cystic fibrosis
  - » Low levels may be found in vegetarians/vegans
- **Common Approaches for Addressing Low Pancreatic Digestive Enzyme Levels:**
  - » Digestive support with betaine HCL

- » Chew thoroughly and relax at meal time
- » Pepsin
- » Plant or pancreatic enzyme supplements
- » Digestive herbs
- » Bile salts
- » Taurine
- » Consider underlying causes

**Table 8.** Staging of pancreatic insufficiency based on fecal elastase-1.

Fecal Elastase-1 Result	Clinical Significance
< 200 ug/g	Pancreatic insufficiency
200–500 ug/g	Decreased pancreatic output
> 500 ug/g	Normal pancreatic output

## Steatocrit

Fecal fats are normally emulsified by bile salts and absorbed in the small intestines. High levels of fat in the stool may be an indication of maldigestion, malabsorption, or steatorrhea.

- **Causes of Elevated Steatocrit:**
  - » Hypochlorhydria
  - » Maldigestion
  - » Malabsorption
  - » Pancreatic insufficiency (*see elastase-1*)
  - » Bile salt insufficiency
  - » Improper mastication
  - » Celiac disease
- **Therapeutic Approaches and Considerations for High Fecal Fats:**
  - » Support digestion with betaine HCL
  - » Pepsin
  - » Digestive herbs or “bitters”
  - » Bile salts
  - » Taurine
  - » Consider underlying causes of malabsorption, such as celiac disease, dysbiosis, or food sensitivities

## ADDITIONAL GI MARKERS

### Beta-Glucuronidase

High levels of fecal beta-glucuronidase can indicate unfavorable metabolic changes in the colon. Beta-glucuronidase may indicate dysbiosis and interference with Phase II detoxification involving glucuronidation.

- **Major Producers of  $\beta$ -glucuronidase are:**
  - » *Bacteroides fragilis*
  - » *Bacteroides vulgatus*
  - » *Bacteroides uniformis*
  - » *Clostridium paraputrificum*
  - » *Clostridium clostridioforme*
  - » *Clostridium perfringens*
  - » *Escherichia coli*
  - » *Eubacterium*
  - » *Peptostreptococcus*
  - » *Ruminococcus*
  - » *Staphylococcus*
- **Clinical Indications of High  $\beta$ -glucuronidase:**
  - » Dysbiosis in the colon or small intestinal bacterial overgrowth (SIBO)
  - » Extremely elevated cases associated with colon cancer risk
  - » Problems with detoxification, especially estrogen (*via glucuronidation pathway*)
  - » Overexposure to toxins or drugs
- **Therapeutic Approaches and Considerations for Elevated  $\beta$ -glucuronidase:**
  - » Address dysbiosis, if present
  - » Promote bacterial diversity with probiotics, fiber, prebiotics, and fermented foods
  - » Consider liver support such as milk thistle and calcium D-glucarate, especially if patient is taking hormone replacement or has increased cancer risk
  - » If there are no signs of dysbiosis on the GI-MAP, consider a SIBO breath test

### Occult Blood Fecal Immunochemical Testing (FIT)

FIT is quantitative and directly measures the concentration of hemoglobin present in stool, rather than just the qualitative presence of hemoglobin. This test uses antibodies specific for human hemoglobin and therefore does not require dietary restrictions or multiple samples, significantly reducing the appearance of false positives. This method has better detection of lower hemoglobin concentrations than qualitative tests, eliminating potential false negatives as well. Literature suggests a result of 10 ug/g may be indicative of potentially more serious conditions such as polyps or colorectal cancer. A variety of ailments can cause lower counts of blood in stool, such as hemorrhoids, anal fissures, pathogenic infection such as giardia, liver disease, and upper GI infections.

- **Possible Causes of Positive Occult Blood:**
  - » Bleeding ulcer
  - » Inflammatory bowel disease
  - » Cancer
  - » Intestinal polyps
  - » Upper GI bleeds that cause iron deficiency anemia
- **Common Approaches for Addressing Fecal Occult Blood**
  - » Identify source
  - » Follow-up testing recommended

## IMMUNE RESPONSE

### Secretory IgA (SIgA)

Immunoglobulin A is the primary immunoglobulin in the intestinal mucosa. It represents a “first line of defense” in response to antigens and pathogens in the GI and respiratory tracts. In addition to protecting against pathogens, SIgA plays a major role in helping to maintain balance in the microbiome and protecting against exposure to food-derived antigens.

**Low Fecal SIgA** – The gut immune system is suppressed. Investigate underlying causes, such as chronic dysbiosis, antigen exposure, chronic stress, immunocompromised patient, or even protein malnutrition.

- **Therapeutic Approaches for Low SIgA Levels:**
  - » Address any chronic GI infections, if appropriate
  - » Address microbiome imbalances
  - » Address chronic stress and adrenal health, if needed
  - » Colostrum or immunoglobulins
  - » Supplement with *S. Boulardii*
  - » GI mucosal support with glutamine
  - » Lactobacillus and Bifidobacteria probiotics
  - » General immune support
  - » Essential fatty acids
  - » Zinc
  - » Address other imbalances on the GI-MAP

**High Fecal SIgA** – Elevated immune response to antigens in the GI tract. Investigate underlying causes, such as chronic dysbiosis, acute infections, acute stress, or food sensitivities.

- **Therapeutic Approaches for High SIgA Levels:**
  - » Address GI infections
  - » Address any food allergies and sensitivities
  - » General immune support

**Anti-gliadin SIgA** – Gliadin is a component of gluten, the protein found in wheat and other field grass grains such as barley, malt, and rye. The presence of fecal anti-gliadin antibodies can indicate an immune response (*in the gut*) to gluten in the diet. Fecal anti-gliadin antibodies do not necessarily correlate with blood levels.

**High Anti-gliadin SIgA** – Elevated immune response to gliadin in the lumen of the gut.

- **Treatment:**
  - » Consider gluten elimination for a trial period
  - » If patients have been gluten-free, consider hidden sources of gluten and gliadin cross-reactive food such as dairy, corn, oats, millet, rice and yeast
  - » Consider intestinal barrier support, including supplements such as L-glutamine, zinc carnosine, and colostrum

## **Eosinophil Activation Protein (EDN/EPX)**

EDN/EPX is a protein released by activated eosinophils which has strong cytotoxic characteristics. The protein plays a significant role in a variety of inflammatory and mast-cell mediated pathologies in addition to fighting pathogens, particularly viral infections.

### **High Eosinophil Activation Protein –**

The accumulation of eosinophil activation protein in the intestine is associated with inflammation and tissue damage, and the level of EPA in the stool can serve as an objective measure for chronic inflammation in the GI tract. In the case of inflammatory bowel disease, the marker can be used to evaluate disease activity and predict relapse. The EPA marker can also be used to determine the effectiveness of a food elimination diet to control symptoms or disease progression.

- **Possible Causes of Elevated Eosinophil Activation Protein:**
  - » Respiratory allergies
  - » Asthma
  - » Food allergies and sensitivities
  - » IBD
  - » IBS
  - » Eosinophilic esophagitis (EE)
  - » Functional dyspepsia
  - » Acid reflux
  - » Intestinal barrier damage/dysfunction
  - » Anxiety (IBS-related anxiety)
  - » Intestinal parasites

## INFLAMMATION

### Calprotectin

Fecal calprotectin is the most studied marker of gastrointestinal inflammation. High calprotectin indicates neutrophil infiltration to the gut mucosa. Calprotectin is the gold standard marker for the diagnosis and monitoring of inflammatory bowel disease. It is used to differentiate IBD from irritable bowel syndrome.

- **Possible Causes of Elevated Calprotectin**
  - » Intestinal infections and pro-inflammatory dysbiosis
  - » Food allergens, toxins and certain drugs (*e.g., non-steroidal anti-inflammatory drugs [NSAIDs]*)
  - » Inflammatory bowel disease
  - » Polyps
  - » Diverticulitis
  - » Colorectal cancer
- **Therapeutic Approaches and Considerations**
  - » Address possible causes of elevated calprotectin
  - » Persistently elevated calprotectin may indicate chronic inflammatory disease; further evaluation by a qualified medical professional is advised
  - » Consider anti-inflammatory support (*e.g., anti-inflammatory diet, curcumin, omega-3 fatty acids, aloe, and resveratrol*)

## ADD-ON TESTS

### Zonulin

Zonulin is a protein that opens intercellular tight junctions in the gut lining (*the connections between epithelial cells that make up the gastrointestinal lining*). Zonulin increases intestinal permeability in the jejunum and ileum and is considered a biomarker for barrier permeability.

- **Therapeutic Approach for Elevated Intestinal Permeability:**
  - » Address dysbiosis (*pathogens and opportunistic microbe overgrowth, lack of beneficial microbes*)
  - » Eliminate gluten, address potential food sensitivities
  - » Promote a healthy intestinal barrier with L-glutamine, butyrate, essential fatty acids, aloe vera, probiotics, zinc carnosine, slippery elm, marshmallow, deglycyrrhizinated licorice

# ANTIBIOTIC RESISTANCE GENES

The GI-MAP includes results for detection of *H. pylori* antibiotic resistance genes. If an antibiotic resistance gene is present, then that class of antibiotics is designated POSITIVE for antibiotic resistance. A positive result for the presence of resistance genes for a given antibiotic indicates that the antibiotic is not an ideal choice for an antibiotic protocol. Since microbes can rapidly share DNA under stress, the presence of antibiotic resistance is reason enough to avoid that drug class.

H. PYLORI ANTIBIOTIC RESISTANCE GENES		
	Result	Reference
<b>Amoxicillin</b>	<b>Positive</b>	<b>Negative</b>
Genes associated with amoxicillin resistance		
PBP1A S414R	<b>Present</b>	
PBP1A T556S	<b>Absent</b>	
PBP1A N562Y	<b>Absent</b>	
	Result	Reference
<b>Clarithromycin</b>	<b>Positive</b>	<b>Negative</b>
Genes associated with clarithromycin resistance		
A2142C	<b>Absent</b>	
A2142G	<b>Absent</b>	
A2143G	<b>Present</b>	
	Result	Reference
<b>Fluoroquinolones</b>	<b>Negative</b>	<b>Negative</b>
Genes associated with fluoroquinolone resistance		
gyrA N87K	<b>Absent</b>	
gyrA D91N	<b>Absent</b>	
gyrA D91G	<b>Absent</b>	
gyrB S479N	<b>Absent</b>	
gyrB R484K	<b>Absent</b>	
	Result	Reference
<b>Tetracycline</b>	<b>Negative</b>	<b>Negative</b>
Genes associated with tetracycline resistance		
A926G	<b>Absent</b>	
AGA926-928TTC	<b>Absent</b>	

**Figure 4.** *H. pylori* Antibiotic Resistance Genes. See additional details in the “*Helicobacter pylori*” section of this guide (Page 17, Figure 2).

# GI-MAP PATTERNS

## UNDERSTANDING COMMON DYSBIOSIS PATTERNS WITH GI-MAP

### INSUFFICIENCY DYSBIOSIS

Insufficiency dysbiosis is characterized by low levels of beneficial bacteria that provide critical support for healthy intestinal and immune function. Insufficient levels of beneficial bacteria may result in an elevated risk of intestinal infections, increased intestinal barrier permeability, decreased protective factors such as secretory IgA, and increased inflammation. Lack of keystone bacteria is common in autoimmune, allergic, and chronic inflammatory conditions.

**Table 9.**

Markers Characterizing Insufficiency Dysbiosis	
Commensal/Keystone Bacteria: (low levels)	<i>Bacteroides fragilis</i> <i>Bifidobacterium</i> spp. <i>Enterococcus</i> spp. <i>Escherichia</i> spp. <i>Lactobacillus</i> spp. <i>Akkermansia muciniphila</i> <i>Faecalibacterium prausnitzii</i> <i>Roseburia</i> spp.
Phyla Microbiota: (low levels)	<i>Bacteroidetes</i> <i>Firmicutes</i>
Associated Intestinal Health Markers:	Secretory IgA (often low to very low levels) Zonulin (sometimes elevated)

## INFLAMMATORY DYSDIOSIS

Inflammatory dysbiosis is characterized by moderate to high levels of certain pathogens, normal microbiota, and opportunistic microbes that promote inflammation and increased intestinal permeability. Many pro-inflammatory microbes are gram-negative bacteria that belong to the Proteobacteria phylum and produce a form of lipopolysaccharide (LPS) that is a potent activator of inflammatory responses. This pattern is common in chronic immune and inflammatory conditions.

**Table 10.**

Markers Characterizing Inflammatory Dysbiosis	
Pathogens (low to high levels)	<i>Campylobacter</i> <i>C. difficile</i> <i>Pathogenic E. coli</i> <i>Salmonella</i> <i>Vibrio cholerae</i> <i>Yersinia enterocolitica</i> <i>Giardia</i>
Commensal/Keystone Bacteria (low levels)	<i>Escherichia</i> spp. <i>Enterobacter</i> spp.
Opportunistic Bacteria, Yeast, and Protozoa (moderate to high levels)	<i>Morganella</i> spp. <i>Pseudomonas</i> spp. <i>Pseudomonas aeruginosa</i> <i>Desulfovibrio</i> spp. <i>Citrobacter</i> spp. <i>Citrobacter freundii</i> <i>Klebsiella</i> spp. <i>Klebsiella pneumoniae</i> <i>Proteus</i> spp. <i>Proteus mirabilis</i> <i>Fusobacterium</i> spp. <i>Candida</i> spp. <i>Candida albicans</i> <i>Parasitic protozoa (specifically Giardia and Blastocystis hominis)</i>
Associated Intestinal Health Markers:	$\beta$ -Glucuronidase (may be elevated) Occult Blood-FIT (may be elevated) Secretory IgA (often low levels, but sometimes elevated) Calprotectin (often elevated, but sometimes very low levels) Eosinophil Activation Protein (EDN/EPX) (may be elevated) Zonulin (may be elevated in some cases)

## DIGESTIVE DYSFUNCTION DYSBIOSIS

Dysbiosis associated with digestive dysfunction is very common, and is often due to low stomach acid (hypochlorhydria), insufficient bile acids, poor digestion (*pancreatic insufficiency or brush border enzyme deficiency*), reduced absorption, and altered gastrointestinal motility. Altered digestion and motility can result in imbalances in the microbiome, characterized by overgrowth of certain species. Symptoms associated with digestive dysfunction include but are not limited to: excessive gas and bloating, abdominal discomfort, dyspepsia, heart burn, gastroesophageal reflux (GERD), constipation or diarrhea, food sensitivities and intolerances.

**Table 11.**

Markers Associated with Digestive Dysfunction	
Pathogens ( <i>low to high levels</i> )	Most types, especially if multiple pathogens are present
H. pylori ( <i>moderate to high levels</i> )	<i>Helicobacter pylori</i> ( <i>with or without virulence factors</i> )
Commensal/Keystone Bacteria ( <i>high levels</i> )	<i>Enterococcus</i> <i>Lactobacillus</i> <i>Clostridium</i>
Phyla Microbiota ( <i>high levels</i> )	<i>Bacteroidetes</i> and/or <i>Firmicutes</i>
Opportunistic Bacteria, Yeast, and Protozoa ( <i>moderate to high levels</i> )	<i>Bacillus</i> spp. <i>Enterococcus faecalis</i> <i>Enterococcus faecium</i> <i>Morganella</i> spp. <i>Staphylococcus</i> spp. <i>Staphylococcus aureus</i> <i>Streptococcus</i> spp. <i>Methanobacteriaceae</i> (family) <i>Desulfovibrio</i> spp. <i>Klebsiella pneumoniae</i> <i>Prevotella</i> <i>Candida</i> spp. <i>Candida albicans</i> <i>Parasitic protozoa</i>
Intestinal Health Markers:	Elastase-1 ( <i>often low to moderately low levels</i> ) Steatocrit ( <i>sometimes elevated</i> )

## PATTERNS ASSOCIATED WITH IMMUNE-MEDIATED FOOD REACTIONS

The GI-MAP™ (Microbial Assay Plus) can be used in conjunction with IgG Food Explorer™ and IgE Allergy Explorer™ to dig deeper into the root cause of adverse food reactions. If the gut barrier is permeable and/or digestion is suboptimal, maldigested food proteins can trigger immune system responses.

These are the key patterns to look for on the GI-MAP that are connected food sensitivities and allergies.

**Table 12.**

Food Intolerance, Allergy, and Adverse Food Reactions Pattern			
Histamine Producing Bacteria	Morganella spp.	High	Opportunists (page 3)
	Pseudomonas spp.		
	Pseudomonas aeruginosa		
	Citrobacter freundii		
	Klebsiella spp.		
	Klebsiella pneumoniae		
	Proteus spp.		
	Proteus mirabilis		
	Enterobacter spp.		
	Escherichia spp.		
Fusobacterium spp.			
Mast Cell-Activating Bacteria	H. Pylori	High	H. Pylori Panel (page 2)
	Enterococcus faecalis	High	Opportunists (page 3)
	Pseudomonas aeruginosa		
	Staphylococcus aureus		
	Streptococcus spp.		
	Candida spp.	High	Fungi/Yeast (page 3)
	Candida albicans		
Lipopolysaccharide producers	High	Throughout report	
Commensal/Keystone Bacteria	Lactobacillus spp.	Low	Commensal/Keystone Bacteria (page 2)
Intestinal Health Markers	Eosinophil Activation Protein (EDN/EPX)	High	Intestinal Health Markers (page 4)
	SIgA		
	Anti-gliadin IgA		
	Zonulin		

Continued...

Table 12a.

Gut Barrier Permeability (“Leaky Gut”) Pattern			
Intestinal Permeability	Any Pathogen	High	Pathogens (page 1)
	<i>Lactobacillus spp.</i>	Low	Commensal/Keystone Bacteria (page 2)
	<i>Akkermansia muciniphila</i>	Low; <dl	
	<i>Candida albicans</i>	High	Fungi/Yeast (page 3)
	Anti-gliadin IgA	High	Intestinal Health Markers (page 4)
	Zonulin		
Low Butyrate/SCFA Production	<i>Faecalibacterium prausnitzii</i>	Low; <dl	Commensal/Keystone Bacteria (page 2)
	<i>Roseburia spp.</i>	Low	
	<i>Firmicutes phylum</i>		
Poor Mucosal Health	<i>Bifidobacterium spp.</i>	Low; <dl	Commensal/Keystone Bacteria (page 2)
	<i>Escherichia spp.</i>	Low	
	<i>Lactobacillus spp.</i>		
	<i>Akkermansia muciniphila</i>	Low; dl	
	<i>Bacteroidetes phylum</i>	Low	

Table 12b.

Digestive Insufficiency Pattern			
Digestive Insufficiency	<i>Firmicutes</i> phylum	High	Commensal/Keystone Bacteria (page 2)
	Bacteroidetes phylum		
	<i>Enterococcus</i> spp.		
	<i>Lactobacillus</i> spp.		
	<i>Akkermansia muciniphila</i>		
	<i>Bacillus</i> spp.	High	Opportunists (page 3)
	<i>Enterococcus faecalis</i>		
	<i>Enterococcus faecium</i>		
	<i>Staphylococcus</i> spp.		
	<i>Staphylococcus aureus</i>		
	<i>Streptococcus</i> spp.		
	<i>Desulfovibrio</i> spp.		
	Methanobacteriaceae (family)		
	<i>Fusobacterium</i> spp.		
	Steatocrit	Detected; High	Intestinal Health Markers (page 4)
	Pancreatic Elastase-1	Low	

## GAS & HISTAMINE PRODUCERS ON GI-MAP

Table 13.

Primary Hydrogen Producers	<i>Faecalibacterium prausnitzii</i>
	<i>Roseburia</i> spp.
	<i>Bacteroidetes</i> phyla
	<i>Firmicutes</i> phyla
Primary Methane Producers	<i>Methanobacteriaceae</i> (family)
Primary Hydrogen Sulfide Producers	<i>Bacteroides fragilis</i>
	<i>Escherichia</i> spp.
	<i>Enterobacter</i> spp.
	<i>Desulfovibrio</i> spp.
	<i>Morganella</i> spp.
	<i>Pseudomonas aeruginosa</i>
	<i>Staphylococcus aureus</i>
	<i>Citrobacter</i> spp.
	<i>Citrobacter freundii</i>
	<i>Klebsiella</i> spp.
	<i>Klebsiella pneumoniae</i>
	<i>Proteus</i> spp.
	<i>Proteus mirabilis</i>
	<i>Fusobacterium</i> spp.
Histamine Producing Bacteria	<i>Lactobacillus</i> spp.
	<i>Morganella</i> spp.
	<i>Pseudomonas</i>
	<i>Pseudomonas aeruginosa</i>
	<i>Citrobacter freundii</i>
	<i>Klebsiella</i>
	<i>Klebsiella pneumoniae</i>
	<i>Proteus</i>
	<i>Proteus mirabilis</i>
	<i>Enterobacter</i> spp.
	<i>Escherichia</i> spp.
	<i>Fusobacterium</i> spp.



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Download a GI-MAP® Sample Report at:  
[diagnosticsolutionslab.com/tests/gi-map](http://diagnosticsolutionslab.com/tests/gi-map)

**Diagnostic Solutions**  
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877-485-5336

**Patient: Ima Sample**  
Collected: 08/02/2022  
DOB: 07/11/1981  
Gender: M

**Accession: 0000000-0091**  
Received: 08/02/2022  
Completed: 8/17/2022  
Ordered by: Diane Farhi, MD

**GI-MAP**  
DNA STool ANALYSIS BY QUANTITATIVE PCR

**YOUR PERSONALIZED REPORT**

**PATHOGENS**

The GI-MAP® includes pathogens (bacterial, parasitic and viral) commonly known to cause gastroenteritis. Note that not all individuals with positive findings will present with symptoms. Many factors, including the health of the individual (such as immune health, digestive function, and microbiome balance), the transient nature of most pathogens, and the presence and expression of virulence factors, all contribute to pathogen virulence and individual symptoms.

Pathogen	Result	Reference
<b>BACTERIAL PATHOGENS</b>		
<i>Campylobacter</i>	< dl	< 1.00e3
<i>C. difficile</i> Toxin A	1.21e5 High ↑	< 1.00e3
<i>C. difficile</i> Toxin B	2.27e5 High ↑	< 1.00e3
Enterohemorrhagic <i>E. coli</i>	< dl	< 1.00e3
<i>E. coli</i> O157	< dl	< 1.00e3
Enteroinvasive <i>E. coli</i> /Shigella	< dl	< 1.00e3
Enterotoxigenic <i>E. coli</i> LT/ST	< dl	< 1.00e2
Shiga-like Toxin <i>E. coli</i> stx1	< dl	< 1.00e3
Shiga-like Toxin <i>E. coli</i> stx2	< dl	< 1.00e3
Salmonella	< dl	< 1.00e3
<i>Vibrio cholerae</i>	< dl	< 1.00e4
<i>Yersinia enterocolitica</i>	< dl	< 1.00e5
<b>PARASITIC PATHOGENS</b>		
Cryptosporidium	4.46e3	< 1.00e5
<i>Entamoeba histolytica</i>	< dl	< 1.00e6
Giardia	< dl	< 1.00e4
<b>VIRAL PATHOGENS</b>		
Adenovirus 40/41	< dl	< 5.00e3
Norovirus GI/II	< dl	< 1.00e10
	< dl	< 1.00e7

**KEY:** Results are reported as genome equivalents per gram of stool, which is a standard method for estimating the number of microbes measured per gram of stool, based on qPCR analysis of DNA templates.  
Results are expressed in standard scientific notation. For example, a reported result of 3.5e7 is equivalent to 3.5 x 10<sup>7</sup> microbes per gram, which equals 35,000,000 (35 million) microbes per gram of stool.  
• dl represents results below detectable limit.

The assays were developed and/or the performance characteristics determined by Diagnostic Solutions Laboratory.

CLIA# 11D-2097795  
Medical Director - Diane Farhi, MD

# INTERPRETIVE GUIDE

## GI-MAP® – Unparalleled DNA Based Stool Testing

Our mission: to deliver innovative, accurate and clinically relevant diagnostic testing in a timely and cost-effective manner



GI Microbial Assay Plus

[diagnosticsolutionslab.com](http://diagnosticsolutionslab.com)