Overview

Useful For
Rapid detection of gastrointestinal infections caused by:

- *Campylobacter* species (*Campylobacter jejuni/Campylobacter coli/Campylobacter upsaliensis*)
- *Clostridioides (Clostridium) difficile* toxin A/B
- *Plesiomonas shigelloides*
- *Salmonella* species
- *Vibrio* species (*Vibrio parahaemolyticus, Vibrio vulnificus, Vibrio cholerae*)
- *Vibrio cholerae*
- *Yersinia* species
- Enteroaggregative *Escherichia coli* (EAEC)
- Enteropathogenic *E coli* (EPEC)
- Enterotoxigenic *E coli* (ETEC)
- *Shiga toxin*
- *E coli* O157
- *Shigella/Enteroinvasive E coli* (EIEC)
- *Cryptosporidium* species
- *Cyclospora cayetanensis*
- *Entamoeba histolytica*
- *Giardia*
- Adenovirus F 40/41
- *Astrovirus*
- *Norovirus* GI/GII
- Rotavirus A
- Sapovirus

This test is **not recommended** as a test of cure.
Highlights
The FilmArray gastrointestinal panel is a multiplex PCR test capable of qualitatively detecting DNA or RNA of 22 pathogens (bacteria, parasites, and viruses) in approximately 1 hour from feces in Cary Blair transport medium.


Testing Algorithm
The following algorithms are available in Special Instructions:

- Parasitic Investigation of Stool Specimens Algorithm
- Laboratory Testing for Infectious Causes of Diarrhea

Special Instructions
- Parasitic Investigation of Stool Specimens Algorithm
- Laboratory Testing for Infectious Causes of Diarrhea

Method Name
Multiplex Polymerase Chain Reaction (PCR)

NY State Available
Yes

Specimen

Specimen Type
Fecal

Advisory Information
It is not recommended that the following tests be concomitantly ordered if this test is ordered:

- VIBC / *Vibrio* Culture, Feces
- ROTA / Rotavirus Antigen, Feces
- LADV / Adenovirus, Molecular Detection, PCR, Varies
- GIAR / *Giardia* Antigen, Feces
- CRYPS / *Cryptosporidium* Antigen, Feces
- CYCL / *Cyclospora* Stain, Feces
- STL / Enteric Pathogens Culture, Feces
- CAMPC / *Campylobacter* Culture, Feces
-SHIGC / *Shigella* Culture, Feces

-SALMC / *Salmonella* Culture, Feces

-YERSC / *Yersinia* Culture, Feces

-E157C / *Escherichia coli* O157:H7 Culture, Feces

-STFRP / Shiga Toxin, Molecular Detection, PCR, Feces

-CDFRP / *Clostridioides* (*Clostridium*) *difficile* Toxin, Molecular Detection, PCR, Feces

**Additional Testing Requirements**

In some cases, there may be local public health requirements that impact Mayo Clinic Laboratories (MCL) clients and require additional testing on specimens with positive results from this panel. Clients should familiarize themselves with local requirements. MCL recommends clients retain an aliquot of each specimen submitted for this test to perform additional testing themselves, as needed. If necessary, see Interpretation for detailed information about how to obtain this testing.

**Shipping Instructions**

**Specimen must arrive within 96 hours of collection.**

**Specimen Required**

**Supplies:** C and S Vial (T058)

**Specimen Type:** Preserved feces

**Container/Tube: Cary-Blair transport system is required.** Specific for recovery of enteric pathogens from fecal specimens (15 mL of non-nutritive transport medium containing phenol red as a pH indicator, either Cary-Blair or Para-Pak C and S). Submit sample in original Cary Blair medium container (not an aliquot).

**Specimen Volume:** 1 gram or 5 mL

**Collection Instructions:**

1. Collect fresh fecal specimen and place in preservative within 2 hours of collection.

2. Submit a representative portion of feces in container with transport medium.

**Forms**

If not ordering electronically, complete, print, and send 1 of the following forms with the specimen:

- [Microbiology Test Request](#) (T244)

- [Gastroenterology and Hepatology Client Test Request](#) (T728)

**Specimen Minimum Volume**

1 mL

**Reject Due To**
Test Definition: GIP
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| Commercial transport media other than liquid Cary Blair (eg, ETM, Para-Pak Enteric Plus; Copan FecalSwab/ESwab) Cary Blair gel swab Products containing formalin SAF PVA fixative EcoFix preservative Rectal swab Stool swab Gel swab Endoscopy specimen Unpreserved stool | Reject |

Specimen Stability Information

<table>
<thead>
<tr>
<th>Specimen Type</th>
<th>Temperature</th>
<th>Time</th>
<th>Special Container</th>
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<tbody>
<tr>
<td>Fecal</td>
<td>Ambient (preferred)</td>
<td>4 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Refrigerated</td>
<td>4 days</td>
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</table>

Clinical and Interpretive

Clinical Information

Acute diarrheal syndromes are usually self-limiting, but may be complicated by dehydration, vomiting, and fever. Diagnostic testing and treatment may be required in some instances. Many bacterial enteric infections in the United States originate within the food supply chain. According to the CDC, in 2012 there were 19,531 laboratory-confirmed cases of infection with pathogens potentially transmitted through food in the United States. The number of infections, by pathogen, were as follows: *Salmonella* species (7,800), *Campylobacter* species (6,793), *Shigella* species (2,138), *Cryptosporidium* species (1,234), Shiga toxin-producing *Escherichia coli* non-O157 (551), Shiga toxin-producing *E. coli* O157 (531), *Vibrio* species (193), *Yersinia* species (155), and *Cyclospora cayetanensis* (15). *Giardia* may also be transmitted through ingestion of contaminated food and water. There were 15,178 cases of giardiasis reported to the CDC in 2012. Since the clinical presentation may be very similar to many of these bacterial, viral, and parasitic pathogens, laboratory testing is required for definitive identification of the causative agent.

Rapid multiplex panel detection of the most common agents of bacterial, viral, and parasitic enteric infections directly from stool specimens is sensitive, specific, and provides same-day results, obviating the need for culture, antigen testing, microscopy, or individual nucleic acid amplification tests.

For other diagnostic tests that may be of value in evaluating patients with diarrhea the following are available in Special Instructions:

- **Parasitic Investigation of Stool Specimens Algorithm**
- **Laboratory Testing for Infectious Causes of Diarrhea**

Reference Values

Negative (for all targets)

Interpretation

A negative result should not rule-out infection in patients with a high pretest probability for gastrointestinal infection. The assay does not test for all potential infectious agents of diarrheal disease.
Positive results do not distinguish between a viable or replicating organism and the presence of a nonviable organism or nucleic acid, nor do they exclude the potential for coinfection by organisms not contained within the panel.

Results of the panel are intended to aid in the diagnosis of illness and are meant to be used in conjunction with other clinical and epidemiological findings.

In some cases, there may be local public health requirements that impact Mayo Clinic Laboratories (MCL) clients and require additional testing on specimens with positive results from this panel. Clients should familiarize themselves with local requirements. MCL recommends clients retain an aliquot of each specimen submitted for this test to perform additional testing themselves, as needed. If necessary, selected add-on tests can be performed by MCL at an additional charge, as detailed below. **Call 800-533-1710 within 96 hours of specimen collection to request supplemental testing for positive test results:**

<table>
<thead>
<tr>
<th>Gastrointestinal Pathogen Panel Positive for</th>
<th>Client Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Campylobacter</em> species</td>
<td>Request add on test: CAMPC / <em>Campylobacter</em> Culture, Feces</td>
</tr>
<tr>
<td><em>Salmonella</em> species</td>
<td>Request add on test: SALMC / <em>Salmonella</em> Culture, Feces</td>
</tr>
<tr>
<td><em>Shigella/Enteroinvasive E coli</em></td>
<td>Request add on test: SHIGC / <em>Shigella</em> Culture, Feces (for the <em>Shigella/Enteroinvasive E coli</em> target, the culture will assess for <em>Shigella</em> species only)</td>
</tr>
<tr>
<td><em>Yersinia</em> species</td>
<td>Request add on test: YERSC / <em>Yersinia</em> Culture, Feces</td>
</tr>
<tr>
<td><em>Vibrio</em> species</td>
<td>Request add on test: VIBC / <em>Vibrio</em> Culture, Feces</td>
</tr>
<tr>
<td><em>Shiga toxin-producing E coli</em></td>
<td>Request add on test: E157C / <em>Escherichia coli</em> O157:H7 Culture, Feces</td>
</tr>
</tbody>
</table>

MCL will report results to the client for additional cultures when ordered. If cultures are positive and the client is in need of the isolated organism (eg, *Campylobacter*, *Salmonella*, *Shigella*, *Yersinia* or *Vibrio* species, or *E coli* O157:H7) for submission to a public health laboratory, the client needs to call MCL and request that the isolates be returned to them (the client). The client will be responsible for submitting the isolates to the appropriate public health department. Positive culture results will also be reported via the Electronic Clinical Laboratory Reporting System (ECLRS).

Alternatively (not preferred), clients who want a patient specimen returned from MCL should call 800-533-1710 as soon as possible, at the latest within 96 hours of specimen collection, to request that MCL return an aliquot of the submitted specimen to them. Clients will be responsible for submitting specimens to appropriate public health departments.

**Cautions**

The detection of microbial DNA or RNA is dependent upon proper sample collection, handling, transportation, storage, and preparation. There is a risk of false-negative results due to the presence of strains with sequence variability or genetic rearrangements in the target regions of the assays.
Repeat testing should not be performed on samples collected less than 7 days apart.

The presence of blood or mucous in the sample may interfere with testing.

*Aeromonas* species are not detected by this panel, but may be detected by tests STL / Enteric Pathogens Culture, Feces or AERMC / *Aeromonas* Culture, Feces.

The following information is provided by the test manufacturer:

Cary Blair media, used for dilution and processing of clinical stools, is screened by manufacturers for viable organisms but may not be specifically tested for microbial nucleic acids. The presence of nucleic acids at levels that can be detected by the FilmArray GI Panel may lead to false positive test results. (BioFire Technical Notes FLM1-PRT-0239-01 and QS-339B-01.)

**Campylobacter species:** Detects but does not differentiate *C. jejuni*, *C. coli*, and *C. upsaliensis*. Other species will not be detected. *Helicobacter pullorum* may cross react.

**Clostridioides (Clostridium) difficile:** Detects but does not differentiate toxin A gene (*tcdA*) and toxin B gene (*tcdB*). A positive result may reflect asymptomatic carriage or *C. difficile*-associated diarrhea.

**Salmonella species:** Detects but does not differentiate *S. enterica* and *S. bongori*. Cross-reactivity may occur with some strains of *Escherichia coli*, which have the cryptic ETT2 type-III secretion system.

**Vibrio species:** Detects but does not differentiate *V. parahaemolyticus* and *V. vulnificus*. The assay may also react with less common *Vibrio* species such as, *V. alginolyticus*, *V. fluvialis*, and *V. mimicus*. The assay is not expected to detect rare species of *Vibrio* such as: *V. cincinnatiensis*, *V. furnissii* and *V. metschnikovii*. *Grimontia hollisae* may cross react.

**Vibrio cholerae:** *V. cholerae* is specifically reported when detected. *V. cholerae* strains that do not carry the *toxR* gene or which carry highly divergent *toxR* genes may not be detected. Rare non-*cholerae* strains of *Vibrio* that have acquired the *toxR* gene may cross-react (eg, *V. harveyi*, *V. mimicus*, *V. alginolyticus*, *V. vulnificus*).

**Yersinia species:** Detects *Y. enterocolitica* but does not differentiate known serotypes or biotypes. *Y. kristensenii*, *Y. frederiksenii*, and *Y. intermedia* cross-react at high levels with *Y. enterocolitica*; detection is reported to genus level only.

**Diarrheagenic *Escherichia coli***: Detects genetic determinants associated with classic diarrheagenic *E coli/Shigella* pathotypes. Transfer of these genes between organisms has been documented; therefore, detected results for multiple diarrheagenic *E coli/Shigella* may be due to the presence of multiple pathotypes or a single strain containing the genes characteristic of multiple pathotypes.

**Enteroaggregative *Escherichia coli*** (EAEC): Detects but does not differentiate 2 gene targets typically associated with enteroaggregative *E coli*; the *aggR* regulatory gene and the putative outer membrane protein, *aatA*, both located on the partially-conserved pAA plasmid. pAA is not present in all strains phenotypically identified as EAEC, and not all pAA plasmids carry *aggR* and *aatA* genes; therefore, the assay will not detect all members of this diverse pathotype, but is likely to detect most pathogenic strains.

**Enterotoxigenic *Escherichia coli*** (ETEC): Detects but does not differentiate heat-labile (LT) enterotoxin (*ltA*) and 2 heat-stable (ST) enterotoxin variants (*st1a* and *st1b*). Cross-reactivity may occur with strains of *Hafnia alvei*, *Citrobacter koseri*, *Citrobacter sedlakii*, and *Cedecea davisae*. LT-II and the STB/ST2 toxins are not detected.

**Enteropathogenic *Escherichia coli*** (EPEC): Detects *eae* gene but does not differentiate typical and atypical
EPEC. The LEE pathogenicity island, which includes the eae gene, is also found in some Shiga toxin-producing *Escherichia coli* (STEC; O157 and non-O157 strains). Therefore, the results of the eae assay (positive or negative) are only reported when STEC is not detected. When STEC is detected, EPEC will not be reported, regardless of the EPEC assay result. Consequently, the assay cannot distinguish between STEC containing *eae* and a coinfection of EPEC and STEC. Rare instances of other organisms carrying *eae* have been documented (eg, *Aeromonas* species, *Citrobacter* species, *E. albertii*, *Shigella boydii*). Others assays target *bfp* to detect EPEC and, if positive, reflex to *eae* detection to characterize isolates as typical or atypical EPEC. The *bfp* gene is not used to detect EPEC in this assay. For the reasons described above, EPEC may be missed or overcalled.

**Shiga toxin-producing Escherichia coli (STEC):** Detects but does not differentiate Shiga toxin 1 (*stx1*) and Shiga toxin 2 (*stx2*) sequences. Shiga toxin-positive results indicate the likely presence of Shiga toxin-producing *Escherichia coli*. Rare instances of detection of Shiga-like toxin genes in other genera and species have been reported (eg, *Aeromonas caviae*, *Acinetobacter haemolyticus*, *Shigella sonnei*, *Enterobacter cloacae*, *Citrobacter freundii*, *Klebsiella pneumoniae*).

**Escherichia coli O157:** The *Escherichia coli* O157 assay is not reported as detected unless a Shiga-like toxin gene is also detected. The assay cannot distinguish between infections with a single toxigenic STEC O157 or rare coinfections of STEC (non-O157) with a *stx1/stx2*-negative *E. coli* O157.

**Shigella/Enteroinvasive E. coli (EIEC):** Detects but does not differentiate *Shigella* species from enteroinvasive *E. coli*.

**Cryptosporidium species:** Detects but does not differentiate approximately 23 different *Cryptosporidium* species, including the most common species (eg, *C. hominis* and *C. parvum*), as well as less common species (eg, *C. meleagridis*, *C. felis*, *C. canis*, *C. cuniculus*, *C. muris*, and *C. suis*), but is not expected to detect the very rare species *C. bovis*, *C. ryanae*, and *C. xiaoii*.

**Entamoeba histolytica:** Detects *E. histolytica*. *E. dispar* present in high levels may cross-react.

**Giardia:** Detects *G. lamblia* (also known as *G. intestinalis*, *G. duodenalis*). A very low frequency of cross-reactivity with the commensal microorganisms *Bifidobacterium* and *Ruminococcus* species was observed in the clinical evaluation.

**Adenovirus F40/41:** Detects but does not differentiate F40 and F41. Does not detect respiratory adenovirus species such as B, C, and E.

**Astrovirus:** Detects but does not differentiate 8 subtypes (HAstV1-8).

**Norovirus GI/GII:** Detects but does not differentiate GI and GII. Does not detect genogroup GIV, nonhuman genogroups, or closely related Caliciviruses.

**Rotavirus:** Detects all strains of rotavirus A. In silico sequence analysis indicates that these assays will not cross-react with rotavirus B and C, which are less common in human disease, or rotavirus D, E, and F, which have not been found in humans. Recent oral rotavirus A vaccines may result in patients passing the virus in stool and be detectable in stool PCR testing. Contamination of specimens with vaccine can cause false-positive rotavirus PCR results. Specimens should not be collected or processed in areas that are exposed to rotavirus A vaccine material.

**Sapovirus:** Detects but does not differentiate genogroups I, II, IV, V. Genogroup III will not be detected.(FilmArray Gastrointestinal [GI] Panel CE IVD, BioFire Diagnostics, LLC, Salt Lake City, Utah)

**Supportive Data**

The BioFire FilmArray Gastrointestinal Panel is an FDA-cleared assay for testing Cary-Blair-preserved stool. A performance verification study of the FilmArray Gastrointestinal Panel was completed at Mayo Clinic (Rochester
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Minnesota.(1) Five hundred clinical stool specimens (retrospective/stored samples=270; prospective samples=230) were evaluated. Results were compared to a reference standard result, which was defined as an organism identified by routine culture, microscopy, or a consensus (2 out of 3) result obtained by molecular and/or antigen assays. Among 500 clinical stool samples, the assay showed greater than 90% agreement for all targets. Several targets, including *Plesiomonas shigelloides*, *Cyclospora cayetanensis*, *Entamoeba histolytica*, *Vibrio* species, and enterotoxigenic *Escherichia coli* did not have an adequate number of positive samples to rigorously assess the sensitivity of these targets.

In order to supplement the data derived from clinical samples, spiking studies were completed to evaluate the accuracy of all targets, including those that could not be analyzed by clinical specimens alone. This group included: *Campylobacter* species (n=4), *A Clostridium difficile* (n=4), *Plesiomonas shigelloides* (n=4), *Salmonella* species (n=4), *Yersinia enterocolitica* (n=4), *Vibrio cholerae* (n=4), enteroaggregative *E coli* (n=4), enteropathogenic *E. coli* (n=4), enterotoxigenic *E coli* (n=4), *E coli O157* (n=4), *Shigella* species (n=8), *Cryptosporidium* species (n=4), *Cyclospora cayetanensis* (n=8), *Entamoeba histolytica* (n=4), *Giardia lamblia* (n=4), adenovirus 40/41 (n=4), norovirus (n=8), rotavirus A (n=4), sapovirus (n=4), and astrovirus (n=8). All targets demonstrated 100% agreement with the expected result during the spiking studies.

Clinical Reference

Performance

Method Description
The FilmArray Gastrointestinal Panel is a closed system that performs the chemistry required to isolate, amplify, and detect nucleic acid from multiple viral, bacterial, and parasitic gastrointestinal pathogens from a single stool specimen of patients suspected to have a gastrointestinal infection. A panel contains reagents in freeze-dried form and is divided into discrete segments where the required chemical processes are carried out. Patient sample and hydration fluid are drawn by vacuum into the panel and then placed into the FilmArray instrument. The detection process operations are automated (nucleic acid purification, first-stage PCR, second-stage PCR, and melt analysis) and complete in about an hour in this closed system:

-Nucleic Acid Purification:

The sample is lysed by a combination of chemical and mechanical mechanisms and the liberated nucleic acid is
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captured, washed and eluted using magnetic bead technology.

-First-Stage PCR:

A reverse transcription step is performed to convert viral RNA into cDNA prior to amplification. The purified nucleic acid solution is combined with a preheated master mix to initiate the reverse transcription step and subsequent thermocycling for multiplex PCR.

-Second-Stage PCR:

Products of first stage PCR are diluted and mixed with fresh PCR reagents containing an intercalating fluorescent DNA dye (LCGreen Plus, BioFire Diagnostics), which is distributed over the second stage PCR array. The individual wells of the array contain primers for different assays (in triplicate) that target specific nucleic acid sequences from each of the pathogens detected, as well as control template material.

-DNA Melting Analysis:

Temperature is slowly increased and fluorescence in each well of the array is monitored and analyzed to generate a melt curve.

-Analysis of Melt Curves:

The software evaluates the DNA melt curve for each well to determine if a PCR product was present in that well. If the melt profile indicates the presence of a PCR product, then the analysis software calculates the melting temperature of the curve, which is then compared against the expected range for the assay. When the software determines that the melt curve is positive and in range, it is called positive. When it determines that the melt curve is negative or is not in the appropriate range, it is called negative.

-Analysis of Replicates:

Melt curves of each of the 3 replicates for each assay are evaluated to determine the assay result. For an assay to be called positive, at least 2 of the 3 associated melt curves must be called positive, and the temperature for at least 2 of the 3 positive melt curves must be similar (within 1 degree C). Assays that do not meet these criteria are called negative. (Instruction manual: FilmArray Gastrointestinal [GI] Panel CE IVD, BioFire Diagnostics, LLC, Salt Lake City, Utah, RFT-PRT-0143-04 June 2017)

PDF Report

No

Day(s) and Time(s) Test Performed

Monday through Sunday

Analytic Time

1 day

Maximum Laboratory Time

2 days

Specimen Retention Time

7 days

Performing Laboratory Location
Fees and Codes

Fees
- Authorized users can sign in to Test Prices for detailed fee information.
- Clients without access to Test Prices can contact Customer Service 24 hours a day, seven days a week.
- Prospective clients should contact their Regional Manager. For assistance, contact Customer Service.

Test Classification
This test has been cleared or approved by the U.S. Food and Drug Administration and is used per manufacturer’s instructions. Performance characteristics were verified by Mayo Clinic in a manner consistent with CLIA requirements.

CPT Code Information
0097U

LOINC® Information

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<th>Test Order Name</th>
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