RESEARCH PAPER

Etiological Spectrum and Antibiotic Resistance Patterns in Acute Gastroenteritis

Mani Srikanth Manam[1], Deva K S[2], Uthamchand K[3] and Srininvasagalu Krishnasamy[4]*

[1]*Senior Resident, Department of General Medicine, Meenakshi Medical College Hospital and Research Institute, Kanchipuram, Tamil Nadu, Meenakshi Academy of Higher Education and Research, Chennai.*
[2]*Postgraduate, Department of General Medicine, Meenakshi Medical College Hospital and Research Institute, Kanchipuram, Tamil Nadu, Meenakshi Academy of Higher Education and Research, Chennai*
[3]*Assistant Professor, Department of General Medicine, Meenakshi Medical College Hospital and Research Institute, Kanchipuram, Tamil Nadu, Meenakshi Academy of Higher Education and Research , Chennai*
[4]*Professor, Department of General Medicine, Meenakshi Medical College Hospital and Research Institute, Kanchipuram, Tamil Nadu, Meenakshi Academy of Higher Education and Research , Chennai*
[1]*kinnu.srikanth@gmail.com,* [3]*chandmbbs94@gmail.com and* [4]**galusrinivasan@gmail.com*

Received: 24th Feb, 2026; Revised: 17th March 2026; Accepted: 4th April, 2026; Available Online: 20h April, 2026

ABSTRACT

Acute gastroenteritis (AGE) is among the top causes of morbidity across the world especially in third world countries. It is brought about by various bacterial, viral and parasitic infections. The development of antimicrobial resistance among bacterial agents also makes issues in managing the same even more complicated. The purpose of the study was to identify the etiological spectrum of acute gastroenteritis and to evaluate the situation with antibiotic resistance of bacteria isolates. Routine microscopy, culture and multiplex polymerase chain reaction (PCR) were used to analyze stool samples of patients who presented with acute diarrhea. A great number of pathogens were detected, which were bacterial organisms (Escherichia coli, Salmonella spp., Shigella spp.), viral, and parasitic organisms. Multiplex PCR exhibited a greater level of detection than the conventional methods. Ample resistance was noted against the widely used antibiotics with and improved sensitivity on higher generation antibiotics. In due course, acute gastroenteritis is induced by a wide variety of pathogens, and the growing antimicrobial resistance emphasizes the importance of rational use of antibiotics. Multiplex PCR is a useful diagnostic method in the quick and precise detection of pathogens.

Keywords: *Acute gastroenteritis, Etiological spectrum, Multiplex PCR, Antibiotic resistance, Enteric pathogens.*
How to cite this article: Manam MS, Deva KS, Uthamchand K, Krishnasamy S. Etiological Spectrum and Antibiotic Resistance Patterns in Acute Gastroenteritis. Int J Drug Deliv Technol. 2026;16(31s):76-82. DOI: 10.25258/ijddt.16.31s.10
Source of support: Nil.
Conflict of interest: None

1. INTRODUCTION

Acute gastroenteritis (AGE) is a highly prevalent infectious agent in the world, as well as one of the major sources of morbidity and mortality, especially in the low- and middle-income nations. It is defined by abrupt diarrhea which can be accompanied by vomiting, pains in the abdomen, fever, and dehydration. Even with the improvement in health care, AGE remains a massive burden to the health system of a society as it is highly prevalent, particularly in children, the elderly, and immunocompromised persons. Etiology of acute gastroenteritis is eclectic and includes an extensive variety of bacterial, viral and parasitic etiological factors. Escherichia coli, Salmonella spp., Shigella spp., and Campylobacter spp. are the most common bacteria agents involved.

Viral pathogens: Rotavirus and norovirus have been found to contribute significantly especially in children population whereas parasitic infections like Giardia lamblia and Entamoeba histolytica are common in high densities of poor sanitation. These pathogens vary in their location distribution, seasonal distributions, hygiene practices and socioeconomic statuses. Poor sanitation, poor drinking water, overcrowded and inaccessibility of health services are factors in creating a high incidence of AGE in developing countries. Also, the transmission may occur through foodborne, and contaminated food and water are significant pathogens. Malnutrition and ignorance on hygienic practices only increase the burden. To manage and prevent complications in patients, it is necessary to identify the causative agent accurately and in time.

Conventionally, there has been a high usage of diagnostic practices like stool culture and microscopy. Although these techniques are cost-effective, they are limited to some of them such as low sensitivity, long turnaround times, and unable to detect some fastidious or non-culturable

**Author for Correspondence: galusrinivasan@gmail.com*

organisms. Over the past few years, the advent of multiplex polymerase chain reaction (PCR) assays has been a major advancement in the realm of diagnostics because now a variety of gastrointestinal pathogens could be detected with much more sensitivity and specificity within a relatively short period of time. Acute gastroenteritis is treated mostly by supportive means, but antibiotic treatment is recommended in selected bacterial infections, especially in severe cases or susceptible patients. The excessive and frequently unreasonable use of antibiotics, unfortunately, has resulted in the development of antimicrobial resistance in enteric pathogens. Increased resistance has recently been noted to commonly used antibiotics including ampicillin, cotrimoxazole and fluoroquinolones, which is a significant problem to effective treatment. Multidrug-resistant strains also make clinical management more difficult, and lead to a higher risk of treatment failure, extended morbidity, and reduced healthcare expenditure. This is highly important because it is also necessary to monitor the trend of antimicrobial resistance so that to guide empirical therapy and formulate local treatment guidelines.

Regular monitoring studies are necessary to know the changing trends of resistance and to prevent the unreasonable use of antibiotics. Moreover, the incorporation of new diagnostic systems like multiplex PCR with the traditional ones will help to improve the results of pathogen detection and at the same time, a possibility of antimicrobial susceptibility testing is observed. It is here that, the current research was conducted to examine etiological range of acute gastroenteritis and to determine the trend of resistance to antibiotics in bacterial isolates of patients in a tertiary care facility. Also, the research will evaluate the usefulness of multiplex PCR in enhancing the diagnostic yield in comparison to the traditional techniques. This study is likely to be useful in the clinical management of acute gastroenteritis, antimicrobial stewardship, and community-wide efforts to prevent acute gastroenteritis.

2. MATERIALS AND METHODS

Study Design

This paper was developed in the form of a prospective hospital-based observational study to assess the etiology spectrum and pattern of antibiotic resistance among individuals with acute gastroenteritis. The research was carried out in six months between October 2025 and March 2026.

Study Setting

The research was conducted in the Department of General Medicine of Meenakshi Medical College Hospital and Research institute, Kanchipuram, Tamil Nadu, India. It is a tertiary care teaching hospital that serves both rural and urban population within and around the Kanchipuram district.

Inclusion and Exclusion Criteria.

The study included patients of all ages who had acute diarrhea or liquid stools three or more times daily with or without vomiting, fever, abdominal pain, or dehydration and the illness duration was not more than 14 days. The patients were not included in the study: patients who had chronic diarrhea taking longer than 14 days, patients who received antibiotics in the last 72 hours, patients known to have inflammatory bowel disease, other non-infectious gastrointestinal diseases, or patients with immunocompromised states (such as HIV infection, malignancy, chemotherapy). All the participants were informed and gave a written informed consent before joining the study.

Sample Collection

The stool samples of the enrolled patients were collected in sterile and wide-mouthed containers and immediately taken to the microbiology laboratory to analyze them. To evaluate the consistency of the stool sample, as well as the presence of blood, mucus, or visible parasites, macroscopic analysis of stool samples was conducted.

Microscopy

The direct microscopic examination of stool samples was done with saline and iodine wet mount preparations to identify ova, cysts, parasites, pus cells, and red blood cells. Detection of parasitic infections and inflammatory changes that indicated bacterial infections was done mainly by microscopy.

Stool Culture

Enteric bacterial pathogens including Escherichia coli, Salmonella species, and Shigella species were isolated on stool samples cultured on MacConkey agar, Xylose Lysine Deoxycholate (XLD) agar and Blood agar. Colony morphology and Gram staining, as well as conventional biochemical tests, were used to identify the bacteria isolates.

Multiplex PCR

Detection Multiplex polymerase chain reaction (PCR) was done on a bacterial, viral, and parasitic pathogens directly on a stool sample. A basic extraction kit was used to do the DNA extraction following the instructions provided by the manufacturer. Pathogen-specific primers were used to perform PCR amplification after which detection of amplified products was done using gel electrophoresis.

Susceptibility to Antibiotics Testing.

Kirby Bauer disk diffusion test on Mueller Hinton agar was used to test the antibiotic susceptibility of bacterial isolates. These findings were explained by Clinical and Laboratory Standards Institute (CLSI) guidelines. The antibiotics that were used were ampicillin, amoxicillin-clavulanate, ciprofloxacin, norfloxacin, cotrimoxazole, ceftriaxone, gentamicin and amikacin.

Statistical Analysis

All the data was inputted in the Microsoft excel sheet and calculated with the help of the Statistical Package of Social Sciences (SPSS) software. The continuous variables were coded in terms of mean and standard deviation whereas the categorical ones were in terms of percentages. Categorical variables were compared with the help of the Chi-square test. Continuous variables were also appropriate and the t -test or Mann -Whitney U test was

applied to the student. The logistic regression analysis was conducted to determine factors that were related to the antibiotic-resistant infections. The p-value of lower than 0.05 was regarded as significant.

3. RESULT AND DISCUSSION

Results

The study involving 150 patients with the symptoms of acute gastroenteritis was carried out in October 2025-March 2026. Clinical assessment and laboratory studies were conducted on all of the patients including, stool microscopy, stool culture, and multiplex polymerase chain reaction (PCR). All bacterial isolates used in the study were stool cultures, and antibiotic susceptibility tests were conducted on all of them.

Demographic Characteristics

Out of 150 patients who participated in the research, 88 (58.7 percent) men and 62 (41.3 percent) women participated and thus there was a slight preponderance of males. The age distribution indicated that most of the patients were aged between 21 and 40 years, then 41 60 years. The study population was composed of a smaller proportion of pediatric and old populations. The study population was approximately 36 years old.

Table 1: Demographic Distribution of Study Population

Age Group (years)	Male	Female	Total	Percentage (%)
0–10	12	10	22	14.7%
11–20	10	8	18	12.0%
21–40	28	24	52	34.7%
41–60	20	16	36	24.0%
>60	12	10	22	14.7%
Total	**82**	**68**	**150**	**100%**

A total of 150 patients were included in the study, of which 82 were males and 68 were females. The majority of patients belonged to the age group 21–40 years (34.7%).

Diarrhea and vomiting were the most common conditions in most patients, but many of them also experienced fever, abdominal pain, and dehydration signs. Almost half of the patients were observed to have mild to moderate dehydration with a small number of patients having severe dehydration and it required intravenous fluid therapy.

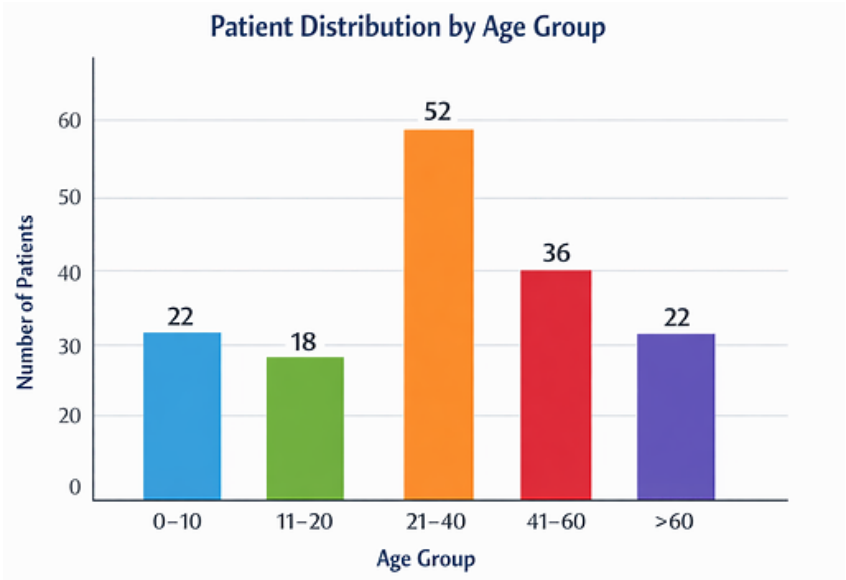

Fig 1: Patient Distribution by Age Group

The **21–40 age group** stands out as the largest segment with 52 patients, while the youngest (0–10) and oldest (>60) groups both have 22 patients each. This kind of visualization makes it easy to spot where the majority of patients fall.

Acute Gastroenteritis: Etiological Spectrum.

Among 150 stool samples, microscopy, culture, and multiplex of PCR revealed that in a considerable proportion of samples, pathogens were found. Bacteria, viruses and parasitic agents were the etiological agents.

The most commonly identified etiological agents were bacterial pathogens and the next were viral and parasitic infections. The most prevalent bacterial pathogen to be isolated was Escherichia coli then Salmonella species and Shigella species. Examples of parasitic infections were Entamoeba histolytica and Giardia lamblia. Multiplex PCR was used in the identification of viral pathogens, which comprised Rotavirus and Norovirus.

Multiplex PCR was found to have higher detection rate than the traditional microscopy and culture. A number of cases that were culture negative were determined culture

positive by PCR, especially of viral pathogens and some bacterial pathogens. This implies that multiplex PCR is a much more sensitive diagnostic method than conventional laboratory method.

Table 2: Etiological Distribution of Acute Gastroenteritis

Pathogen Type	Number of Cases	Percentage (%)
Bacterial	72	48%
Viral	45	30%
Parasitic	21	14%
Mixed Infection	12	8%
Total	**150**	**100%**

Comparison between conventional methods and Multiplex PCR.

Traditional tools like microscopy and cultures detected pathogens in fewer cases than multiplex PCR. Culture of stool proved useful in isolating bacteria and testing their susceptibility to antibiotics but it was not effective in isolating viral pathogens. Microscopy was primarily used in the detection of parasites and was not very sensitive.

Table 3: Bacterial Isolates Identified

Bacterial Organism	Number of Isolates	Percentage (%)
Escherichia coli	32	44.4%
Salmonella spp.	22	30.6%
Shigella spp.	12	16.7%
Vibrio cholerae	6	8.3%
Total	**72**	**100%**

Multiplex PCR was an important advancement in the detection rate of pathogens in that it detected the pathogenic bacteria, viruses and parasites all concurrently. PCR was specifically effective in identification of mixed infections in which more than one pathogen was present. In a low proportion of the cases, mixed infections were also observed, most of them between bacterial and viral pathogens.

The Patterns of the Antibiotic Resistance.

All bacterial isolates were tested using the KirbyBauer disk diffusion test and the results obtained were used to determine the antibiotic susceptibility. Antibiotic resistance pattern presented a high degree of resistance to antibiotics including ampicillin, amoxicillin, and cotrimoxazole which are widely used in most cases. There was moderate resistance against fluoroquinolones including ciprofloxacin and norfloxacin.

Greater generation antibiotics like ceftriaxone, gentamicin and amikacin depicted superior sensitivity patterns than the first-line antibiotics. The sensitivity of Amikacin was greatest compared to other antibiotics that were tested, then ceftriaxone, and gentamicin.

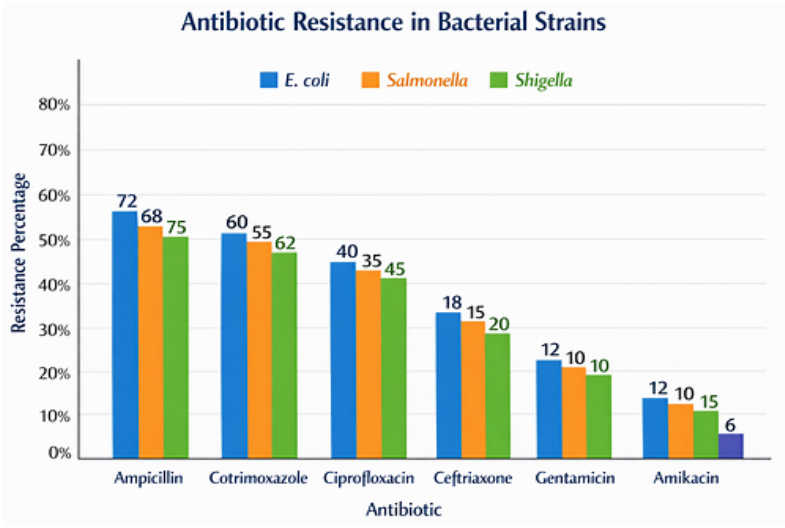

Fig 2: Antibiotic Resistance in Bacterial Strains

Escherichia coli isolates were highly resistant to ampicillin and cotrimoxazole and in some instances Salmonella and Shigella species were found to be resistant to ampicillin and fluoroquinolones. Bacterial isolates that were found to be multidrug resistant demonstrated a high proportion which is of concern to clinical management.

Table 4: Antibiotic Resistance Pattern

Antibiotic	E. coli Resistant %	Salmonella Resistant %	Shigella Resistant %
Ampicillin	72%	68%	75%
Cotrimoxazole	60%	55%	62%
Ciprofloxacin	40%	35%	45%
Ceftriaxone	18%	15%	20%
Gentamicin	12%	10%	15%
Amikacin	5%	4%	6%

High resistance was observed against commonly used antibiotics such as ampicillin and cotrimoxazole, while lower resistance was observed for higher generation antibiotics like ceftriaxone and amikacin.

Correlation of Clinical Severity and Pathogen.

The bacterial patients had higher chances of reporting a fever, abdominal pain, and bloody or mucus stool than the viral cases, which had higher chances of being linked to watery diarrhea and vomiting. Chronic or recurrent diarrhea and abdominal pains were commonly linked with parasitic infections.

Bacterial infections were more related to severe dehydration and hospitalization than viral and parasitic infections. The mixed infections were linked to having a more serious clinical presentation and extended hospital stay.

DISCUSSION

Acute gastroenteritis has been one of the greatest causes of morbidity in many countries around the globe, especially in the developing world such as India where hygiene, sanitation and water quality among others has a great variation. The current research study was done to determine etiological spectrum and antibiotic resistance dynamics among patients with acute gastroenteritis in a tertiary care hospital.

Etiological Spectrum

In the current investigation, bacteria pathogens were the most prevalent cause of acute gastroenteritis, then came viral and parasite infections. Escherichia coli was the most prevalent bacterial pathogen among the isolation followed by Salmonella and Shigella. These results are also in line with various other research studies found in India and other third world countries, where diarrheagenic Escherichia coli have been seen as a significant cause of acute diarrheal disease.

In some cases parasitic infections like Entamoeba histolytica and Giardia lamblia were also detected which showed that food and water were contaminated and contributed to the spread of gastrointestinal infections. In the detection of viral causes of gastroenteritis, the use of multiplex PCR was predominant in the detection of viral pathogens including Rotavirus and Norovirus.

The etiological trend that will be evident in this study resembles findings in other regions in India, where the bacterial pathogens are the major cause of acute gastroenteritis among hospitalized individuals whereas viral infection is more prevalent among the pediatric population.

Role of Multiplex PCR

Among the significant results of this study were the increased rate of identification of the pathogens through multiplex PCR than the traditional techniques like microscopy and culture. The use of multiplex PCR was capable of detecting both bacterial and viral and parasitic pathogens at the same time and was especially helpful in the identification of mixed infections.

The traditional stool culture is regarded as the gold standard of bacterial isolation and antibiotic susceptibility testing though it has drawbacks like long turnaround time and failure to identify viral pathogens. Microscopy can be employed in detecting parasites but has a lower sensitivity and relies much on the proficiency of the laboratory staff.

Multiplex PCR is rapid and accurate in detecting the pathogens and can greatly enhance the process of diagnosis and treatment of acute gastroenteritis. Early diagnosis of the causative organism contributes to the adequate treatment and minimization of unjustified use of antibiotics.

Antibiotic Resistance

Patterns of antibiotic resistance trends were examined by the researchers on a national scale

The pattern of antibiotic resistance that was witnessed in this study was very high in relation to the commonly-used antibiotics like ampicillin, amoxicillin, and cotrimoxazole. This is also in agreement with other past researches which have documented resistance build-up among enteric bacterial pathogens owing to rampant and unreasonable consumption of antibiotics.

There was moderate resistance to fluoroquinolone like ciprofloxacin and norfloxacin that has been widely used in the treatment of bacterial diarrhea. The resistance to fluoroquinolones is growing and this is of concern because these antibiotics were at one time thought to be effective in the treatment of enteric infections.

Greater generation antibiotics like ceftriaxone, gentamicin and amikacin exhibited superior patterns of sensitivity. The antibiotics that were tested in this study indicated that amikacin was the most sensitive. The results indicate that greater generation antibiotics could be more effective in treatment of severe bacterial gastroenteritis, but should be used only in severe cases so as not to promote any further emergence of resistance.

The development of multidrug-resistant organisms is an issue of high importance to the community and it underlines the significance of rational use of antibiotics and antibiotic stewardship programs in hospitals.

Clinical Correlation

Bacterial infections were found to represent more serious clinical manifestations in the form of fever, abdominal pain, blood in stool, and dehydration than the viral infections. Watery diarrhea and vomiting were more likely to be connected with the virus infections. Prolonged diarrhea and abdominal discomfort were likely to be linked with parasitic infections.

The patients with mixed infections were more symptomatic and prolonged their stay in the hospital than single pathogen infections. This points out the significance of proper detection of pathogens in patients with severe gastroenteritis.

Public Health Implications

The results of this research have significant implications on public health. Acute gastroenteritis remains a significant health issue of the developing world because of inadequate facilities to maintain hygiene, unsafe drinking water, and lack of proper hygiene. The measures of prevention, including safe drinking water, good sanitation, hand hygiene, and food safety measures, play a critical role in the prevention of acute gastroenteritis.

The rising cases of antibiotic resistance in enteric pathogens is the key issue and it underscores the importance of rational antibiotic use, antibiotic stewardship programmes and standard monitoring of antibiotic resistance trends in hospitals.

Multiplex PCR is an effective diagnostic method that can be applied in tertiary care hospitals to detect the pathogens swiftly, which can assist in the early diagnosis and consequent suitable treatment and minimization of the unwarranted use of antibiotics.

4. CONCLUSION

The acute gastroenteritis has been a major health issue of concern among populations especially in the third world states, with its high morbidity and the rising cases of antimicrobial resistance amongst bacterial pathogens. As illustrated in the current research, acute gastroenteritis can be caused by a broad spectrum of etiological agents such as bacterial, viral and parasitic pathogens, the most prevalent being the bacterial ones. Escherichia coli was the commonest bacterial isolate with Salmonella and Shigella species coming in second and third place respectively. In comparison to the standard approach of practicing microscopy and culture, Multiplex PCR was found to be more sensitive and quick in pathogen detection and as such it stands out as an effective diagnostic instrument in the early diagnosis of the causative agent of acute gastroenteritis. The early detection assists in proper management of patients and avoidance of complications. The pattern of antibiotic susceptibility which was shown in the current study showed high resistance to the widely used antibiotics like ampicillin and cotrimoxazole with better sensitivity with higher generation antibiotics such as ceftriaxone, gentamicin, and amikacin. This means that the issue of antimicrobial resistance is increasing because of irrational and excessive use of antibiotics. Thus, to have effective treatment guidelines and antibiotic stewardship programs, biomarkers of etiological agents and their resistance to antibiotics should be monitored routinely. To minimize the burden of acute gastroenteritis, rational usage of antibiotics, better sanitation, safe drinking water, and awareness on health among people are required. To keep track of the evolving trends in the pathogen and antimicrobial resistance patterns, it is suggested that further large-scale studies should be conducted.

REFERENCES

1. Montasser K, Osman HA, Abozaid H, et al. Multiplex PCR: Aid to more-timely and directed therapeutic intervention for patients with infectious gastroenteritis. *Medicine*. 2022. DOI: 10.1097/MD.0000000000031022
2. Lakhan C, Badrie N, Ramsubhag A, Indar L. Detection of Foodborne Pathogens in Acute Gastroenteritis Stool Samples Using BioFire PCR Panel. *Microorganisms*. 2022. DOI: 10.3390/microorganisms10081601
3. Zhang H, Morrison S, Tang YW. Multiplex PCR tests for detection of pathogens associated with gastroenteritis. *Clinical Laboratory Medicine*. 2015. DOI: 10.1016/j.cll.2015.02.006
4. Çetin S, Telli E, Şahin AM, et al. Gastrointestinal PCR panel results and antibiotic use in acute gastroenteritis cases. *Indian Journal of Medical Microbiology*. 2024. DOI: 10.1016/j.ijmmb.2024.100536
5. Chang LJ, Hsiao CJ, Chen B, et al. Accuracy and comparison of rapid multiplex PCR tests for gastroenteritis pathogens: systematic review. *BMJ Gastroenterology*. 2021. DOI: 10.1136/bmjgast-2020-000553
6. Hernández RJ, Morales AC, Núñez MM. Impact of multiplex PCR on diagnosis of acute infectious gastroenteritis. DOI: 10.35366/96676
7. Uddin MS, Rahman MM, Faruk MO, et al. Bacterial gastroenteritis in children: etiology and drug resistance study. *Bulletin of National Research Centre*. 2021. DOI: 10.1186/s42269-021-00597-9
8. Molecular and non-molecular approaches to etiologic diagnosis of gastroenteritis. *Advances in Clinical Chemistry*. 2020. DOI: 10.1016/bs.acc.2020.02.007
9. Implementing multiplex-PCR for diagnosis of acute gastroenteritis in hospitalized children. *Journal of Clinical Virology*. 2023. DOI: 10.1016/j.jcv.2023.105577
10. Hall AJ, Wikswo ME, Manikonda K, et al. Acute gastroenteritis surveillance in the United States. *Emerging Infectious Diseases*. DOI: 10.3201/eid1908.130482
11. Bhavnani D, Goldstick JE, Cevallos W, et al. Synergistic effects between rotavirus and coinfecting pathogens. *American Journal of Epidemiology*. DOI: 10.1093/aje/kws220

12. Bettelheim KA, Bennett-Wood V, Lightfoot D. Isolation of verotoxin-producing E. coli in gastroenteritis outbreaks. DOI: 10.1016/S0147-9571(00)00023-0
13. Henke-Gendo C, Harste G, Juergens-Saathoff B. Real-time PCR detects prolonged norovirus excretion. DOI: 10.1128/JCM.00448-09
14. Guerrant RL, Van Gilder T, Steiner TS. Practice guidelines for infectious diarrhea. DOI: 10.1093/clinids/32.3.331
15. Kotloff KL, Nataro JP, Blackwelder WC. Global burden of diarrheal diseases. DOI: 10.2471/BLT.14.139121
16. Troeger C, Forouzanfar M, Rao PC. Global burden of diarrheal diseases study. DOI: 10.1016/S0140-6736(17)32374-8
17. Liu J, Platts-Mills JA, Juma J. Use of quantitative PCR for detection of diarrheal pathogens. DOI: 10.1016/S1473-3099(16)30405-1
18. Buss SN, Leber A, Chapin K. Multicenter evaluation of FilmArray GI Panel. DOI: 10.1128/JCM.02674-14
19. DuPont HL. Acute infectious diarrhea in immunocompetent adults. DOI: 10.1056/NEJMra1601426
20. Thapar N, Sanderson IR. Diarrhea in children: etiology and management. DOI: 10.1016/S0140-6736(03)12973-3
21. Kotloff KL. The burden and etiology of diarrheal illness. DOI: 10.1016/S1473-3099(13)70015-0
22. O'Ryan M, Prado V, Pickering LK. Global burden of rotavirus disease. DOI: 10.1016/S1473-3099(05)70278-1
23. Bardhan P, Faruque ASG, Naheed A. Dehydration in diarrheal disease. DOI: 10.1016/S0140-6736(10)60695-6
24. Kaper JB, Nataro JP, Mobley HL. Pathogenic Escherichia coli. DOI: 10.1038/nrmicro818
25. Engberg J, Neimann J, Nielsen EM. Campylobacter infections epidemiology. DOI: 10.1128/CMR.00029-03
26. Parry CM, Hien TT, Dougan G. Typhoid fever and Salmonella infections. DOI: 10.1056/NEJMra020201
27. Kotloff KL, Winickoff JP, Ivanoff B. Global Shigella infections burden. DOI: 10.2471/BLT.99.01918
28. World Health Organization. Diarrheal disease global report. DOI: 10.2471/BLT.17.203984
29. Taniuchi M, Verweij JJ, Noor Z. High-throughput multiplex PCR for stool pathogens. DOI: 10.1371/journal.pntd.0004388
30. Liu J, Kabir F, Manneh J. Development of multiplex PCR for diarrheal pathogens. DOI: 10.1128/JCM.02674-13