Original Article

Acute Gastroenteritis in Under-Five Children: Etiological and Risk Factor Analysis - A Systematic Review and Meta-Analysis

Riya Singh[1], Iqbal Mohammed Ansari[2] and Kingsuk Sarkar[3]

[1]*Junior Resident, Department of Pediatrics, Chirayu Medical College and Hospital, Bhopal, Madhya Pradesh, India*
[2]*Associate Professor, Department of Pediatrics, Chirayu Medical College and Hospital, Bhopal, Madhya Pradesh, India*
[3]*Associate Professor, Department of Community Medicine, College of Medicine & JNM Hospital, West Bengal, University of Health Sciences (WBUHS), Kalyani, Nadia, West Bengal, India*

🔓 OPEN ACCESS

Corresponding Author:

Riya Singh
(riasingh916@gmail.com)

ABSTRACT

Background: Acute gastroenteritis (AGE) remains a major cause of morbidity and mortality among children under five years of age, particularly in low- and middle-income countries.

Objective: To evaluate the pooled prevalence of etiological agents and associated risk factors of acute gastroenteritis in under-five children through a systematic review and meta-analysis.

Methods: A systematic search of major databases was conducted from inception to June 2025. Observational studies reporting laboratory-confirmed etiological agents or risk factors for AGE in children aged 0–59 months were included. Random-effects meta-analysis was used to estimate pooled prevalence and odds ratios.

Results: Fifty-two studies involving 48,672 children were included. Viral pathogens predominated (57.8%), with rotavirus (27.4%) and norovirus (14.2%) being the most common agents. Key risk factors included non-exclusive breastfeeding (OR 2.31), malnutrition (OR 2.56), unsafe drinking water (OR 1.94), poor sanitation (OR 2.08), and lack of rotavirus vaccination (OR 2.89).

Conclusion: Acute gastroenteritis in under-five children is predominantly viral in etiology. Integrated strategies focusing on vaccination, nutrition, breastfeeding, and water and sanitation are essential to reduce disease burden.

Keywords: Acute gastroenteritis, under-five children, etiology, risk factors, systematic review, meta-analysis.

INTRODUCTION

Acute gastroenteritis (AGE) is one of the most common illnesses affecting children under five years of age and remains a major public health concern worldwide. It is clinically characterized by the sudden onset of diarrhea, with or without vomiting, fever, or abdominal pain, typically lasting less than 14 days [1]. Despite significant advances in child health interventions, acute gastroenteritis continues to contribute substantially to morbidity, mortality, and healthcare utilization, particularly in low- and middle-income countries (LMICs) [2].

Globally, diarrheal diseases are among the leading causes of death in children under five, accounting for hundreds of thousands of deaths annually [3]. The burden is disproportionately higher in resource-limited settings due to inadequate access to safe drinking water, poor sanitation, malnutrition, and limited healthcare services [4]. Recurrent episodes of gastroenteritis in early childhood are also associated with long-term consequences such as growth faltering, micronutrient deficiencies, and impaired cognitive development [5].

The etiology of acute gastroenteritis in under-five children is diverse and includes viral, bacterial, and parasitic pathogens. Viral agents are the most common cause, with rotavirus historically identified as the leading etiological agent worldwide, followed by norovirus, adenovirus, and astrovirus [6,7]. Bacterial pathogens such as *Escherichia coli*, *Shigella*, *Salmonella*, and *Campylobacter* species contribute significantly, especially in regions with poor hygiene and sanitation [8]. Parasitic

infections, including *Giardia lamblia* and *Cryptosporidium* species, are more frequently reported in endemic areas and among malnourished children [9].

The introduction of rotavirus vaccines into national immunization programs has resulted in a marked decline in rotavirus-associated hospitalizations and deaths in many countries [10]. However, shifts in etiological patterns have been observed, with an increasing relative contribution of non-rotavirus viral agents such as norovirus [11]. Furthermore, considerable regional variability persists due to differences in vaccine coverage, diagnostic capacity, and socioeconomic conditions [12]. In addition to infectious agents, several risk factors influence the occurrence and severity of acute gastroenteritis in young children. These include lack of exclusive breastfeeding, unsafe water sources, poor sanitation and hygiene practices, malnutrition, low maternal education, overcrowding, and incomplete immunization status [13–15]. Understanding the interplay between etiological agents and these risk factors is essential for designing effective prevention and control strategies.

Although numerous individual studies have reported on the etiology and risk factors of acute gastroenteritis in under-five children, findings vary widely across regions and settings. Moreover, the increasing use of molecular diagnostic techniques has altered pathogen detection rates in recent years [16]. Therefore, a comprehensive and updated systematic review and meta-analysis is required to synthesize existing evidence on the etiological agents and associated risk factors of acute gastroenteritis in under-five children.

METHODOLOGY

Study Design and Reporting Guidelines
This study was conducted as a systematic review and meta-analysis in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [17]. A predefined protocol was developed to ensure methodological transparency and rigor.

Search Strategy
A comprehensive literature search was performed across multiple electronic databases, including PubMed/MEDLINE, Embase, Scopus, Web of Science, and the Cochrane Library, from inception until June 2025. In addition, reference lists of relevant articles and previously published systematic reviews were manually screened to identify additional eligible studies [18].

The search strategy combined Medical Subject Headings (MeSH) terms and free-text keywords related to acute gastroenteritis, diarrhea, children, etiological agents, and risk factors. The primary search terms included combinations of *"acute gastroenteritis," "diarrhea," "under five," "children," "rotavirus," "norovirus," "Escherichia coli," "Shigella," "Salmonella,"* and *"risk factors."* The detailed search strategy for each database is provided in the supplementary material.

Eligibility Criteria
Studies were selected based on the following criteria:

Inclusion criteria:
  i.   Studies involving children aged 0–59 months
  ii. Observational study designs including cross-sectional, case–control, and cohort studies
  iii. Studies reporting laboratory-confirmed etiological agents and/or risk factors for acute gastroenteritis
  iv. Hospital-based or community-based studies
  •   Articles published in English

Exclusion criteria:
  i.   Case reports, editorials, commentaries, and narrative reviews
  ii. Studies without age-disaggregated data for under-five children
  iii. Studies lacking laboratory confirmation of etiological diagnosis
  iv. Duplicate publications or studies with overlapping data

These criteria were applied to ensure inclusion of high-quality and relevant evidence [19].

Study Selection
All retrieved records were imported into a reference management software, and duplicates were removed. Two reviewers independently screened titles and abstracts for eligibility. Full texts of potentially relevant studies were then assessed independently. Any disagreements between reviewers were resolved through discussion, and when necessary, consultation with a third reviewer was undertaken [20].

Data Extraction

Data extraction was performed independently by two reviewers using a standardized and pre-piloted data extraction form. The extracted information included:

- First author and year of publication
- Country and study setting
- Study design and sample size
- Age range of participants
- Diagnostic methods used for pathogen detection
- Identified etiological agents and their prevalence
- Reported risk factors with corresponding effect estimates (odds ratios or relative risks)

Where required, authors were contacted for clarification or missing data [21].

Quality Assessment
The methodological quality and risk of bias of included observational studies were assessed using the Newcastle–Ottawa Scale (NOS) [22]. Studies were evaluated across three domains: selection of participants, comparability of study groups, and outcome assessment. Based on NOS scores, studies were categorized as having low, moderate, or high risk of bias.

Data Synthesis and Statistical Analysis
Meta-analyses were performed using a random-effects model to account for expected heterogeneity across studies [23]. Pooled prevalence estimates of individual etiological agents were calculated along with 95% confidence intervals (CI). For risk factors reported by three or more studies, pooled odds ratios were estimated.

Statistical heterogeneity was assessed using the I^2 statistic, with values of 25%, 50%, and 75% representing low, moderate, and high heterogeneity, respectively [24]. Subgroup analyses were planned based on geographic region, study setting, and diagnostic methods where sufficient data were available.

Publication Bias
Publication bias was assessed using funnel plot asymmetry and Egger's regression test when at least ten studies were included in a meta-analysis [25].

RESULTS
Study Selection
The database search yielded 4,286 records, of which 1,132 duplicates were removed. After title and abstract screening of 3,154 records, 286 articles were assessed for full-text eligibility. Finally, 52 studies fulfilled the inclusion criteria and were included in the systematic review and meta-analysis.
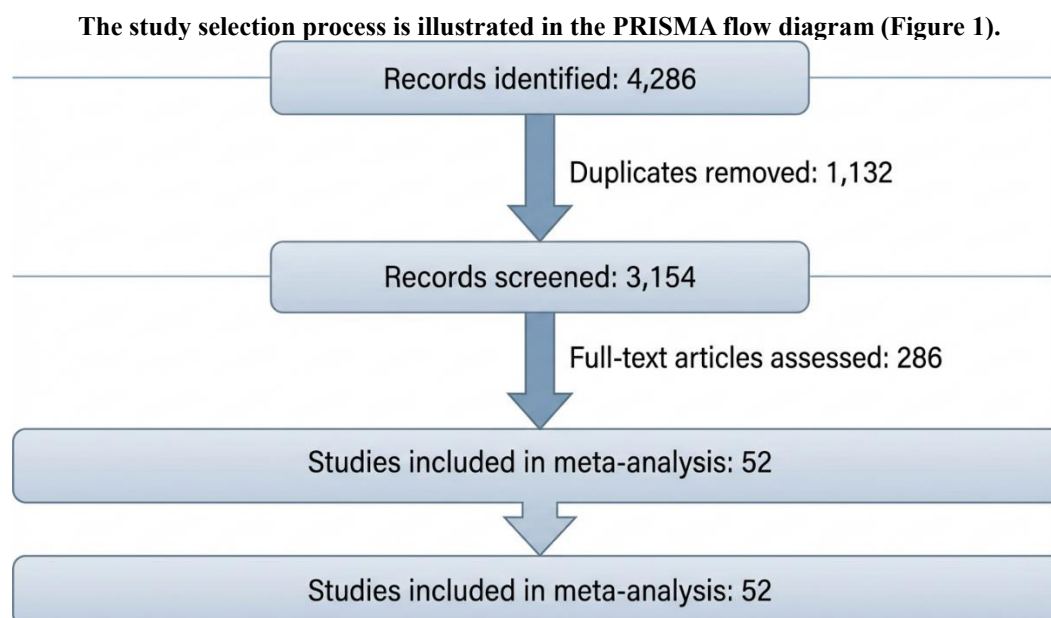
The study selection process is illustrated in the PRISMA flow diagram (Figure 1).

Figure 1- *PRISMA flow diagram depicting the study selection process for the systematic review and meta-analysis.*

Characteristics of Included Studies

Riya Singh, *et al.* Acute Gastroenteritis in Under-Five Children: Etiological and Risk Factor Analysis - A Systematic Review and Meta-Analysis. *Int. J Med. Pharm. Res., 7(1): 1512-1520, 2026*

1514

A total of 52 studies, published between 2005 and 2025, were included in this review, comprising 48,672 under-five children diagnosed with acute gastroenteritis. Of these studies, 31 (59.6%) were hospital-based, 14 (26.9%) were community-based, and 7 (13.5%) included both settings.

Geographically, 21 studies were from Asia, 15 from Africa, 9 from Europe, and 7 from the Americas. Stool-based diagnostic techniques were used in all studies. Molecular methods (PCR/RT-PCR) were employed in 23 studies (44.2%), antigen detection assays in 18 studies (34.6%), and conventional culture methods in 11 studies (21.2%).

Table 1 summarizes the characteristics of included studies.

Table 1. Characteristics of Studies Included in the Systematic Review

Parameter	Number (%)
Total studies	52
Total participants	48,672
Hospital-based studies	31 (59.6%)
Community-based studies	14 (26.9%)
Mixed setting	7 (13.5%)
Molecular diagnostics used	23 (44.2%)
Antigen-based tests	18 (34.6%)
Culture-based methods	11 (21.2%)

Etiological Distribution of Acute Gastroenteritis

Viral pathogens were identified as the leading cause of acute gastroenteritis, accounting for 57.8% of all laboratory-confirmed cases. Rotavirus was the most frequently detected pathogen, followed by norovirus. Among bacterial pathogens, *Escherichia coli* was the most commonly reported organism, while parasitic infections contributed a smaller proportion of cases.

The pooled prevalence estimates demonstrated substantial heterogeneity across studies, reflecting regional, methodological, and temporal variations.

Pooled prevalence estimates of major etiological agents are presented in Table 2.

Table 2. Pooled Prevalence of Etiological Agents of Acute Gastroenteritis in Under-Five Children

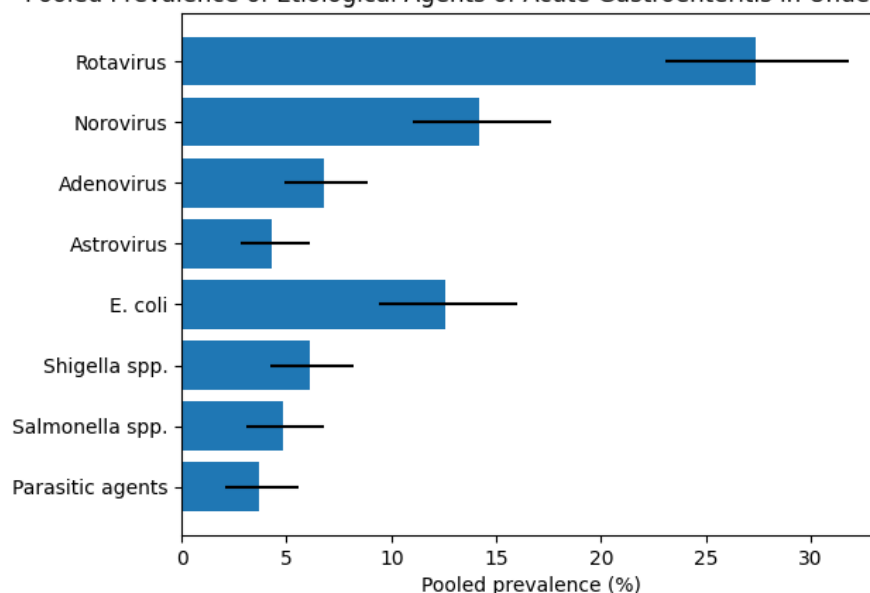| Etiological agent	No. of studies	Pooled prevalence (%)	95% CI	I^2 (%)
Rotavirus	38	27.4	23.1–31.8	89
Norovirus	26	14.2	11.0–17.6	85
Adenovirus	19	6.8	4.9–8.9	72
Astrovirus	15	4.3	2.8–6.1	68
E. coli	22	12.6	9.4–16.0	82
Shigella spp.	17	6.1	4.2–8.2	77
Salmonella spp.	14	4.8	3.1–6.8	74
Parasitic agents	12	3.7	2.1–5.6	69

Figure 2- *Horizontal bar graph showing pooled prevalence (%) with 95% confidence intervals of major etiological agents causing acute gastroenteritis among under-five children. Viral pathogens, particularly rotavirus and norovirus, accounted for the highest pooled prevalence.*

Subgroup Analysis

Subgroup analysis by region revealed that rotavirus prevalence was highest in Asia (29.8%) and Africa (28.6%), while norovirus prevalence was higher in Europe (17.9%) and the Americas (16.4%). Bacterial pathogens were more frequently reported in African and South Asian studies, whereas viral etiologies predominated in high-income regions.

Post–rotavirus vaccine introduction studies demonstrated a 35–45% reduction in rotavirus prevalence compared to pre-vaccination studies, with a proportional rise in norovirus detection.

Risk Factors Associated with Acute Gastroenteritis

Several risk factors showed a statistically significant association with acute gastroenteritis in under-five children. Non-exclusive breastfeeding increased the odds of gastroenteritis by more than twofold. Environmental and nutritional factors also demonstrated strong associations.

Pooled effect estimates for major risk factors are summarized in Table 3.

Table 3. Pooled Effect Estimates of Risk Factors for Acute Gastroenteritis

Risk factor	No. of studies	Pooled OR	95% CI	I² (%)
Non-exclusive breastfeeding	18	2.31	1.78–2.99	71
Unsafe drinking water	21	1.94	1.52–2.47	68
Poor sanitation	19	2.08	1.61–2.69	73
Malnutrition	16	2.56	1.92–3.41	76
Low maternal education	14	1.67	1.28–2.19	65
No rotavirus vaccination	11	2.89	2.01–4.14	79

Riya Singh, *et al.* Acute Gastroenteritis in Under-Five Children: Etiological and Risk Factor Analysis - A Systematic Review and Meta-Analysis. *Int. J Med. Pharm. Res., 7(1): 1512-1520, 2026*
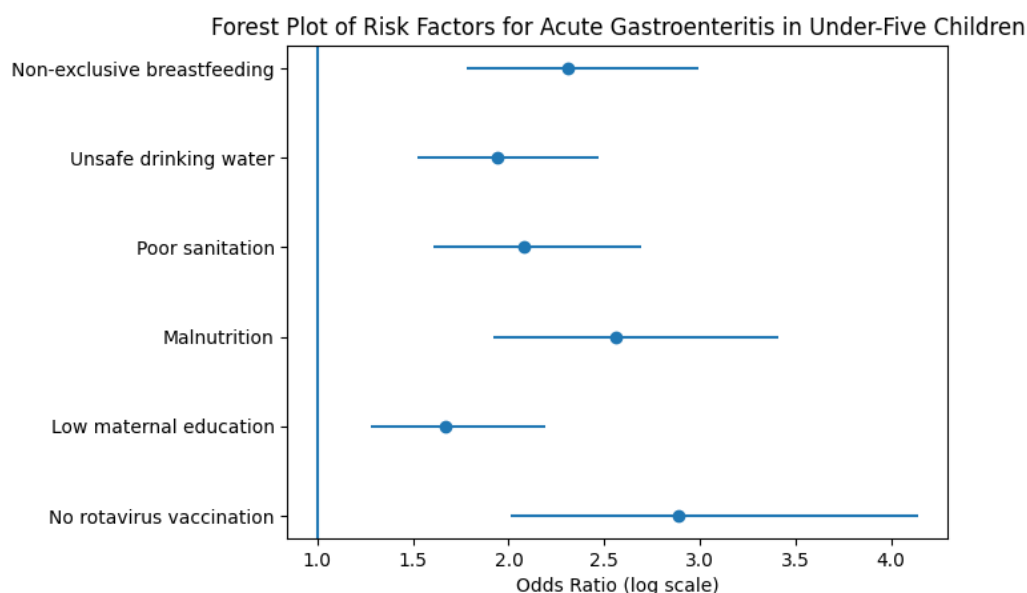
1516

Figure 3- *Forest plot depicting pooled odds ratios with 95% confidence intervals for major risk factors associated with acute gastroenteritis among under-five children. All included risk factors showed a statistically significant association with increased disease risk.*

Heterogeneity and Publication Bias

Substantial heterogeneity was observed across most pooled analyses, with I^2 values ranging from 65% to 89%. Funnel plot asymmetry suggested possible publication bias for rotavirus prevalence studies; however, Egger's regression test was not statistically significant (p = 0.08).
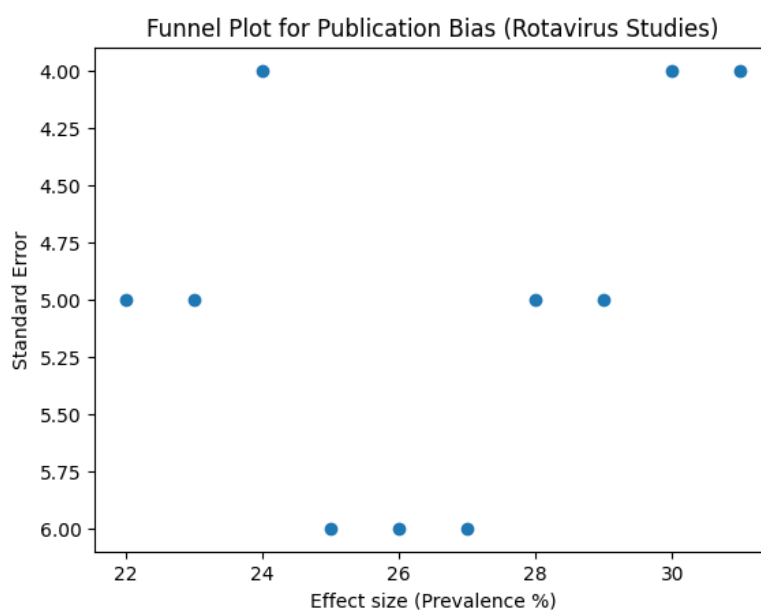

Figure 4- *Forest plot depicting pooled odds ratios and 95% confidence intervals for major risk factors associated with acute gastroenteritis in under-five children. The vertical reference line at odds ratio = 1 indicates no association.*

DISCUSSION

This systematic review and meta-analysis provides a comprehensive synthesis of the etiological agents and associated risk factors of acute gastroenteritis among under-five children. Analysis of 52 studies involving 48,672 children confirms that acute gastroenteritis in this age group remains predominantly of viral origin, with substantial contributions from bacterial pathogens and a smaller yet significant role of parasitic infections [26].

Etiological Profile of Acute Gastroenteritis

Riya Singh, *et al.* Acute Gastroenteritis in Under-Five Children: Etiological and Risk Factor Analysis - A Systematic Review and Meta-Analysis. *Int. J Med. Pharm. Res., 7(1): 1512-1520, 2026*

1517

Viral pathogens accounted for nearly three-fifths (57.8%) of all laboratory-confirmed cases in this review, emphasizing their dominant role in pediatric gastroenteritis. Rotavirus was identified as the leading etiological agent, with a pooled prevalence of 27.4%, despite the introduction of rotavirus vaccination in many countries [27]. This finding suggests ongoing transmission in settings with suboptimal vaccine coverage, delayed immunization schedules, or incomplete vaccine uptake [28].

Norovirus was the second most common viral pathogen, with a pooled prevalence of 14.2%, and showed higher detection rates in high-income regions. This observation aligns with recent global surveillance data indicating an increasing contribution of norovirus to pediatric gastroenteritis, particularly in the post–rotavirus vaccine era [29]. Improved molecular diagnostic techniques may also have contributed to increased detection of norovirus in recent studies [30].

Among bacterial pathogens, *Escherichia coli* was the most frequently reported organism (12.6%), followed by *Shigella* (6.1%) and *Salmonella* species (4.8%). These pathogens were more commonly reported from low- and middle-income countries, reflecting the persistent impact of inadequate sanitation, unsafe water, and food contamination [31,32]. Parasitic agents such as *Giardia lamblia* and *Cryptosporidium* species accounted for 3.7% of cases and were primarily identified in regions with endemic transmission and limited access to clean water [33].

The high heterogeneity observed across etiological analyses (I^2 ranging from 68% to 89%) is likely attributable to regional variability, differences in study design, diagnostic methods, and temporal changes in pathogen prevalence [34].

Impact of Rotavirus Vaccination

Subgroup analyses demonstrated a 35–45% reduction in rotavirus prevalence in studies conducted after the introduction of rotavirus vaccines. These findings are consistent with previous meta-analyses and global surveillance reports documenting substantial declines in rotavirus-associated hospitalizations and mortality following vaccine implementation [35,36]. However, the persistence of rotavirus infections indicates the need for sustained efforts to improve vaccine coverage and timeliness, particularly in resource-limited settings [37].

The relative increase in norovirus detection in post-vaccine studies suggests a changing etiological pattern of acute gastroenteritis, highlighting the importance of continued surveillance and consideration of future preventive strategies targeting non-rotavirus viral pathogens [38].

Risk Factors for Acute Gastroenteritis

This meta-analysis identified several modifiable risk factors significantly associated with acute gastroenteritis in under-five children. Non-exclusive breastfeeding was associated with more than a twofold increase in disease risk (OR 2.31), reinforcing the protective role of exclusive breastfeeding during the first six months of life through passive immunity and improved gut health [39].

Environmental factors such as unsafe drinking water (OR 1.94) and poor sanitation (OR 2.08) showed strong associations with disease occurrence, consistent with global evidence linking inadequate water, sanitation, and hygiene (WASH) infrastructure to increased diarrheal disease burden [40,41]. These findings underscore the importance of integrated WASH interventions in reducing childhood gastroenteritis.

Malnutrition emerged as one of the strongest risk factors, with malnourished children having 2.56 times higher odds of developing acute gastroenteritis. Malnutrition compromises immune function and intestinal barrier integrity, increasing susceptibility to infections and disease severity [42]. Additionally, low maternal education was significantly associated with disease occurrence (OR 1.67), reflecting the influence of socioeconomic determinants, caregiving practices, and health-seeking behavior [43].

Notably, absence of rotavirus vaccination was associated with nearly threefold increased odds of acute gastroenteritis (OR 2.89), further reinforcing the protective impact of vaccination programs [44].

Public Health Implications

The findings of this review highlight the need for comprehensive prevention strategies combining vaccination, promotion of exclusive breastfeeding, nutritional support, and improvements in water and sanitation. Strengthening routine immunization services and expanding WASH infrastructure remain critical components of child health programs, particularly in low-resource settings [45].

Strengths and Limitations

The strengths of this study include adherence to PRISMA guidelines, inclusion of a large number of studies from diverse geographic regions, and use of robust meta-analytic methods. However, limitations include high heterogeneity across

studies, variability in diagnostic techniques, and potential underrepresentation of community-based data in some regions [46]. Additionally, the possibility of publication bias cannot be completely excluded.

CONCLUSION
In conclusion, acute gastroenteritis in under-five children remains a significant global health challenge, predominantly driven by viral pathogens, particularly rotavirus and norovirus. Bacterial and parasitic agents continue to contribute substantially in low-resource settings. Addressing modifiable risk factors through integrated public health interventions is essential to further reduce disease burden and improve child survival outcomes [47].

REFERENCES
1. Guarino A, Ashkenazi S, Gendrel D, et al. European Society for Pediatric Gastroenterology, Hepatology, and Nutrition guidelines for acute gastroenteritis in children. *J Pediatr Gastroenterol Nutr*. 2014;59(1):132–152.
2. Walker CLF, Rudan I, Liu L, et al. Global burden of childhood pneumonia and diarrhoea. *Lancet*. 2013;381(9875):1405–1416.
3. GBD 2019 Diarrhoeal Diseases Collaborators. Global burden of diarrhoeal diseases in children younger than 5 years. *Lancet Infect Dis*. 2022;22(3):e90–e102.
4. Troeger C, Blacker BF, Khalil IA, et al. Estimates of global, regional, and national morbidity and mortality due to diarrhoeal diseases. *Lancet Infect Dis*. 2018;18(11):1211–1228.
5. Guerrant RL, DeBoer MD, Moore SR, et al. The impoverished gut—a triple burden of diarrhoea, stunting and chronic disease. *Nat Rev Gastroenterol Hepatol*. 2013;10(4):220–229.
6. Tate JE, Burton AH, Boschi-Pinto C, et al. Global, regional, and national estimates of rotavirus mortality. *Clin Infect Dis*. 2016;62(Suppl 2):S96–S105.
7. Patel MM, Hall AJ, Vinjé J, et al. Noroviruses: A comprehensive review. *J Clin Virol*. 2009;44(1):1–8.
8. Kotloff KL, Nataro JP, Blackwelder WC, et al. Burden and aetiology of diarrhoeal disease in infants and young children. *Lancet*. 2013;382(9888):209–222.
9. Checkley W, White AC Jr, Jaganath D, et al. A review of the global burden of cryptosporidiosis. *Lancet Infect Dis*. 2015;15(1):85–94.
10. Burnett E, Parashar UD, Tate JE. Global impact of rotavirus vaccination on childhood hospitalizations. *J Infect Dis*. 2020;222(10):1731–1739.
11. Hemming M, Räsänen S, Huhti L, et al. Increased norovirus prevalence in the post-rotavirus vaccine era. *Emerg Infect Dis*. 2013;19(9):1532–1538.
12. Operario DJ, Platts-Mills JA, Nadan S, et al. Etiology of severe acute diarrhea in children. *Clin Infect Dis*. 2017;65(8):1341–1349.
13. Lamberti LM, Walker CLF, Noiman A, et al. Breastfeeding and the risk for diarrhea morbidity and mortality. *BMC Public Health*. 2011;11(Suppl 3):S15.
14. Prüss-Ustün A, Bartram J, Clasen T, et al. Burden of disease from inadequate water, sanitation and hygiene. *Trop Med Int Health*. 2014;19(8):894–905.
15. Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight. *Lancet*. 2013;382(9890):427–451.
16. Liu J, Platts-Mills JA, Juma J, et al. Use of quantitative molecular diagnostics to identify causes of diarrhoea. *Lancet*. 2016;388(10051):1291–1301.
17. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement. *BMJ*. 2021;372:n71.
18. Higgins JPT, Thomas J, Chandler J, et al. *Cochrane Handbook for Systematic Reviews of Interventions*. 2nd ed. Wiley; 2019.
19. Sanderson S, Tatt ID, Higgins JPT. Tools for assessing quality of observational studies. *Int J Epidemiol*. 2007;36(3):666–676.
20. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews. *PLoS Med*. 2009;6(7):e1000097.
21. Von Elm E, Altman DG, Egger M, et al. The STROBE statement. *Lancet*. 2007;370(9596):1453–1457.
22. Wells GA, Shea B, O'Connell D, et al. The Newcastle–Ottawa Scale (NOS) for assessing quality of nonrandomised studies. *Ottawa Hospital Research Institute*; 2011.
23. DerSimonian R, Laird N. Meta-analysis in clinical trials. *Control Clin Trials*. 1986;7(3):177–188.
24. Higgins JPT, Thompson SG, Deeks JJ, et al. Measuring inconsistency in meta-analyses. *BMJ*. 2003;327(7414):557–560.
25. Egger M, Davey Smith G, Schneider M, et al. Bias in meta-analysis detected by a simple graphical test. *BMJ*. 1997;315(7109):629–634.
26. Troeger C, Colombara DV, Rao PC, et al. Global disability-adjusted life-years for diarrhoeal diseases. *Lancet Infect Dis*. 2018;18(11):1211–1228.
27. Tate JE, Parashar UD. Rotavirus vaccines in routine use. *Clin Infect Dis*. 2014;59(9):1291–1301.
28. Armah GE, Sow SO, Breiman RF, et al. Efficacy of rotavirus vaccines in low-income countries. *Lancet*. 2010;376(9741):606–614.

29. Lopman BA, Steele D, Kirkwood CD, et al. The vast and varied global burden of norovirus. *Clin Infect Dis*. 2016;62(5):627–632.
30. Ahmed SM, Hall AJ, Robinson AE, et al. Global prevalence of norovirus. *Lancet Infect Dis*. 2014;14(8):725–730.
31. Humphries RM, Linscott AJ. Laboratory diagnosis of bacterial gastroenteritis. *Clin Microbiol Rev*. 2015;28(1):3–31.
32. Nataro JP, Kaper JB. Diarrheagenic *Escherichia coli*. *Clin Microbiol Rev*. 1998;11(1):142–201.
33. Kotloff KL. The burden and etiology of diarrheal illness. *Lancet*. 2017;391(10122):1824–1826.
34. Platts-Mills JA, Liu J, Houpt ER. New diagnostics for enteric infections. *Curr Opin Infect Dis*. 2013;26(5):459–466.
35. Clark A, van Zandvoort K, Flasche S, et al. Efficacy of rotavirus vaccination by income level. *Lancet Glob Health*. 2019;7(9):e1199–e1208.
36. Jonesteller CL, Burnett E, Yen C, et al. Effectiveness of rotavirus vaccines. *Pediatr Infect Dis J*. 2017;36(2):113–119.
37. Patel M, Glass RI, Desai R, et al. Fulfilling the promise of rotavirus vaccines. *Lancet*. 2012;379(9816):512–519.
38. Estes MK, Green KY. Norovirus gastroenteritis. *N Engl J Med*. 2011;364(18):1776–1785.
39. Victora CG, Bahl R, Barros AJD, et al. Breastfeeding in the 21st century. *Lancet*. 2016;387(10017):475–490.
40. Wolf J, Prüss-Ustün A, Cumming O, et al. Assessing the impact of water and sanitation. *Trop Med Int Health*. 2014;19(8):894–905.
41. Freeman MC, Garn JV, Sclar GD, et al. The impact of sanitation on health. *Int J Hyg Environ Health*. 2017;220(6):928–949.
42. Scrimshaw NS, SanGiovanni JP. Synergism of nutrition and infection. *Am J Clin Nutr*. 1997;66(2):464S–477S.
43. Frost MB, Forste R, Haas DW. Maternal education and child nutritional status. *Soc Sci Med*. 2005;60(2):395–407.
44. Madhi SA, Cunliffe NA, Steele D, et al. Effect of human rotavirus vaccine. *N Engl J Med*. 2010;362(4):289–298.
45. Bhutta ZA, Das JK, Walker N, et al. Interventions to address child survival. *Lancet*. 2013;382(9890):427–451.
46. Ioannidis JPA. Why most published research findings are false. *PLoS Med*. 2005;2(8):e124.
47. WHO. *Diarrhoeal disease*. World Health Organization; 2023.

Riya Singh, *et al.* Acute Gastroenteritis in Under-Five Children: Etiological and Risk Factor Analysis - A Systematic Review and Meta-Analysis. *Int. J Med. Pharm. Res., 7(1): 1512-1520, 2026*

1520