RESEARCH PAPER

Association of Serum Lipopolysaccharide Binding Protein in Gram Negative Bacteria in Acute Infantile Gastroenteritis

Sara Medhat Basha[1], Ahmed S. El-Gayed[2], Maysa Hatem Rashed[3], Manar A. El Desouky[2]

[1] Resident at Pediatric Department, Sheikh Zaid Central Hospital
[2]Pediatric Department, October 6 University
[3] Biochemistry Department, October 6 University

Received 26 July 2026, Revised 28 July 2026, Accepted 20 August 2026, Available Online 22 August 2026

ABSTRACT

Background: Acute gastroenteritis (AGE) is acute diarrheal illness commonly self-limited and sometimes associated with significant mortality and morbidity among infants and young children in developing countries. Identifying the causative pathogen in gastroenteritis may be necessary if antimicrobial treatment is considered. New biomarkers, such as lipopolysaccharide binding protein (LBP) have the potential to determine the cause and outcome of bacterial infectious diseases.

Objective: The study aims to correlate serum Lipopolysaccharide-Binding Protein (LBP) levels with gram negative bacterial infection in infants with acute gastroenteritis compared to conventional inflammatory markers.

Methods**:** This analytical cross-sectional study was performed on 89 infants hospitalized due to acute gastroenteritis to inpatient and intensive care units of October 6 University during the period from September 2025 to May 2026.

Results: Serum lipopolysaccharide binding protein were significantly higher in severe cases, positive cultures, and associated complications. ROC analysis showed that LBP had a high predictive value for bacterial infections with an area under the curve (AUC) 0.956, at a cutoff value of 11 ng/mL, sensitivity was 85.0% and specificity was94.5%.

Conclusion: Serum Lipopolysaccharide-Binding Protein is a reliable diagnostic and prognostic biomarker for gram-negative bacterial infection in infants with acute gastroenteritis. LBP can serve as an adjunctive tool to guide early management of bacterial gastroenteritis in hospitalized infants.

Keywords: Pediatric, infants, Acute gastroenteritis, Lipopolysaccharide binding protein, Bacterial infection

How to cite this article: Association of Serum Lipopolysaccharide Binding Protein in Gram Negative Bacteria in Acute Infantile Gastroenteritis. Association of Serum Lipopolysaccharide Binding Protein in Gram Negative Bacteria in Acute Infantile Gastroenteritis. Int J Drug Deliv Technol. 2026;16(79s):598-605. DOI: 10.25258/ijddt.16.79s.62

.Source of support: None

Conflict of interest: None

INTRODUCTION

Acute infectious gastroenteritis (AGE) is identified based on clinical evaluation. The primary symptoms are abrupt changes in stool consistency and an increased frequency of bowel movements exceeding three times daily, perhaps accompanied by vomiting or fever.[1].

One of the leading causes of infant's death and morbidity globally is acute gastroenteritis [2]. After pneumonia, diarrhea is the leading cause of mortality among children worldwide. Diarrhea affects almost 1.7 billion children annually, putting at least 525,000 lives at danger. [3].

The majority of gastroenteritis cases (50–70 percent) are caused by viruses, with bacteria accounting for fifteen to twenty percent and parasites for ten to fifteen percent [4]. Bacterial enteric pathogens cause numerous infections each year with remarkable morbidity[5]. The most common pathogens include Salmonella, Campylobacter, Shigella, Yersinia enterocolitis, Vibrio cholera, C.difficile, and Escherichia coli, which remains a major cause of acute diarrhea that can lead to complications such as sepsis, seizures, hemolytic uremic syndrome (HUS), and death [6].

There is a lack of precision in the diagnosis of acute gastrointestinal infections using current methods, which include clinical signs, stool cultures, and laboratory studies (particularly C-reactive protein (CRP) level and white blood count). Biomarkers of infections, such as Lipopolysaccharide-binding protein (LBP), which may indicate bacterial infection, have recently been proposed for regular clinical use.[7].

A 50 kDa acute-phase protein called LBP is mostly produced in the liver. It binds strongly to gram-negative bacteria's lipopolysaccharide (LPS), transmits it to CD14 and Toll-like receptor 4 that are linked to the cell membrane, and thus starts the inflammatory cascade in the immune system [8].

Elevated serum LBP levels have been demonstrated in adults and neonates with bacterial infections and sepsis, with diagnostic accuracy superior to procalcitonin and comparable to CRP in certain pediatric populations [9].

However, reported data about the clinical utility of LBP as a biomarker for gram-negative bacterial gastroenteritis in children are still scarce. This study aimed to evaluate serum LBP levels with gram negative bacterial infection in infants with acute gastroenteritis and assess its diagnostic value compared to conventional inflammatory markers.

METHODOLOGY

From September 2025 to May 2026, 89 infants hospitalized to the inpatient and intensive care units of October 6 University Hospital with acute gastroenteritis were the subjects of this cross-sectional analytic research.

Inclusion criteria: Infants aged 2 months to 2 years presenting with acute diarrhea and/or vomiting, both male and female infants.

Exclusion criteria: included infants with chronic intestinal disorder (e.g. inflammatory bowel disease, malabsorption), or suffering from autoimmune disease, immunodeficiency syndromes, or receiving immunosuppressive therapy.

Sample size Estimation: Epi-info program was used to calculate the least sample size, according to the following equation:

N= Z*Z*P*Q/E*e,

where Z=1.96, P= Prevalence, Q=1-P, E=0.05**.** By conducting sample size analysis for a previous study, the least sample size at 0.05 level of significance and power 0.8 is 72 patients[10].

Ethical considerations: (Ethical Code: O6U-ERC: SCCREIRB-MEDICIN6OCT-PU-001-121224-018). The study's design was approved by the local ethics committee at October 6 University's Faculty of Medicine. All participants or their legal guardians gave their written permission after hearing an explanation of the study's purpose and the procedures that would follow.

Methods: all infants were subjected to the following: medical history taking, general and systematic examination, and laboratory investigations were done within the 24 hours of admission:

Routine labs included differential complete blood count, C-Reactive Protein, Arterial blood gases (ABGs), stool culture, serum sodium, potassium, calcium, urea, creatinine.

Special labs included serum lipopolysaccharide binding protein (LBP) determination by ELISA, we measured serum LBP (ng/mL) using the human LBP kit [Cat. No. E0360Hu] from Bioassay Technology Laboratory (China).

Five ml of venous blood samples were extracted from the peripheral veins under sterile conditions. In serum separator tubes, samples were collected and allowed to coagulate for 15 minutes before being centrifuged at 4000X for 10 minutes. Biochemical analysis was performed after the sera were separated. The rest was kept at -80°C until the ELISA analysis was completed.

Statistical Analysis:

The gathered data was examined, categorized, and organized using the Statistical Package for Social Sciences (IBM Corp. Released 2017). IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corporation. Data were categorized and examined based on their classification, with the normality of distribution evaluated by the Shapiro–Wilk test. Descriptive statistics were provided as mean ± standard deviation (SD) for parametric quantitative data and as median with range for non-parametric quantitative data, whilst qualitative data were conveyed as frequency and percentage. For inferential analysis, the Student's t-test was used to assess the means of two independent groups with normal distribution, whilst one-way analysis of variance (ANOVA) was utilized for comparisons involving more than two groups. The Mann–Whitney U test and the Kruskal–Wallis test were used for non-parametric data. The Chi-square test and Fisher's exact test were used to investigate the link between categorical data, whilst correlation analysis was conducted to evaluate the connections among numerical variables. Receiver operating characteristic (ROC) curve analysis was performed to assess diagnostic efficacy, with the ideal cutoff point established according to the area under the curve (AUC), categorized as excellent (0.9–1.0), good (0.8–<0.9), fair (0.7–<0.8), poor (0.6–<0.7), and failed (0.5–<0.6). All p-values were assessed using a two-tailed approach, with a p-value of less than 0.05 being statistically significant at a confidence level of 95%.

RESULTS

A total of 89 infants participated in the study, with ages ranging from 2 months to 2 years, with a mean age of 17.4±6.3 months, infants were mainly males (56.2%), females (43.8%) (Table1). Figure 1 shows E-coli was the most frequent detected organism, identified in 41 cases (46.1%), followed by Salmonella in 13 cases (14.6%), Klebsiella in 12 cases (13.5%), and Yersinia was detected in only one case. No bacterial growth was detected in 22 cases.

The median LBP in the whole studied group was 21.9 ng/ml, as shown in Figure 2.

Table 2 shows the serum LBP levels according to the degree of dehydration. The lowest LBP levels were observed in cases with mild dehydration, increased in moderate cases, and reached the highest levels in severe dehydration ($p<0.001$ for all). Furthermore, serum LBP levels were highly significant in patients with associated complications compared to those without complications ($p <0.005$ for all).

Serum LBP levels were significantly higher in cases with Gram-negative bacteria compared to those with no bacterial growth ($p <0.001$). Based on the identified organisms, the highest serum LBP levels were seen in cases with Klebsiella, followed by Salmonella and E. coli ($p <0.001$) for all comparison, shown in table 3 and Figure 3.

Serum LBP had significant positive correlations with the number of diarrhea motions, WBCs, neutrophils, PLT, CRP, urea, creatinine, and hospital stay duration. On the other hand, it had significant negative correlations with lymphocytes ($p=0.011$), PCO_2, HCO_3 ($p<0.001$ for both), as seen in Table 4.

Analysis of the receiver operating characteristic (ROC) curve assessing the efficacy of serum LBP in forecasting Gram-negative bacteria in stool cultures revealed an area under the curve (AUC) of 0.956, with a cutoff threshold of 11 ng/ml, sensitivity at 85.0%, and specificity at 94.5%, as seen in Figure 4.

Table 1: Demographic characteristics in the studied group

		Study group	
		N=89	Percent (%)
Age (months)	Mean ±SD	17.4±6.3	
	Range	3-24	
Sex	Male	50	56.2%
	Female	39	43.8%
Weight (KG)	Mean ±SD	9.8±1.43	
	Range	5-12.5	
Number of diarrhea motions /day	median	7	
	Range	4-15	
Number of vomiting motions /day	Median	3	
	Range	0-7	
Dehydration status	Mild	13	14.6%
	Moderate	26	29.2%
	Severe	50	56.2%
Stool culture	No growth after 48 hrs aerobic incubation	22	24.7%
	Positive culture	67	75.3%

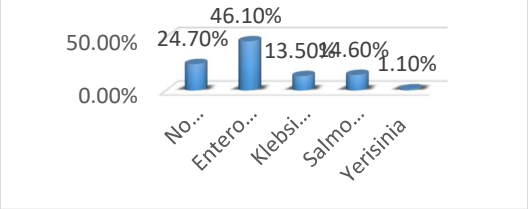

Figure 1: Detected organisms in the studied group

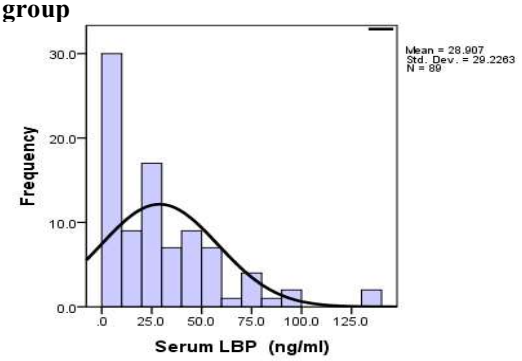

Figure 2: Serum LBP (ng/mL) in the studied group

Table2: Serum LBP level as regards patient's degree of dehydration and associated complications

Dehydration status	Serum LBP (ng/ml) Mean ±SD	Median	Range	Test	P value
Mild	12.8±14.1	6.4	0.4-49.6	W=20.8	<0.001*
Moderate	30.0±29.1	21.8	0.5-99.6		
Severe	43.8±32.1	39.9	2.0-137.8		

No complications	13.3±14.1	4.9	0.3-49.6	W=12.3	<0.005*
Metabolic acidosis	32.7±26.3	18.6	0.3-137		
Shock	46.5±35.9	40.4	2.0-137.8		
Hypernatremia	22.6±21.6	18.2	1.9-51.9		
Hyponatremia	20.5±17.3	21.4	0.5-53.3		
Hypokalemia	17.9±17.1	22.2	0.5-55.2		

W: Kruskal-Wallis test, *: Significant

Table 3: Serum LBP in the studied group as regarding to stool culture

Stool analysis		Serum LBP (ng/ml) Mean ±SD	Median	Range	Test	P value
Culture	**No growth**	2.9±3.1	2.4	0.3-11.5	U=6.7	<0.001*
	Gram negative bacterial infection	37.4±28.9	29.6	1.8-137.8		
Detected organism	**Enteropathogenic E. coli**	23.0±14.3	21.9	1.8-49.6	W=30.7	<0.001*
	Klebsiella	65.3±25.1	73.2	20.0-99.6		
	Salmonella	52.5±36.8	50.7	22.2-137.8		
	Yersinia	20.4	20.4	20.4		

*p value: significant

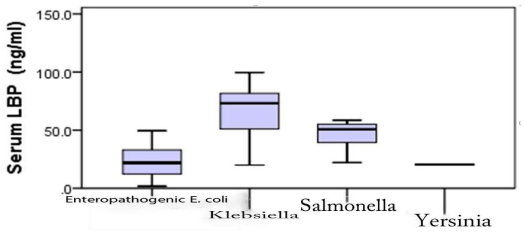

Figure 3: Serum LBP in the studied group as regarding to detected organisms.

Table 4: Correlations between Lipopolysaccharide Binding Protein and patients' clinical data and laboratory investigations.

	Serum LBP (ng/ml)	
	r	**P value**
Age (months)	-0.154	0.149
Number of diarrhea motions	0.447	<0.001*
Vomiting times	0.020	0.840
Hospital stay duration (days)	0.350	<0.001*
WBCS X103 /mm3	0.428	<0.001*
Neutrophil %	0.263	0.013*
Lymphocytes %	-0.268	0.011*
Hemoglobin (g/dl)	-0.050	0.640
PLT X10^3 /mm3	0.362	<0.001*
CRP (mg/L)	0.677	<0.001*
PH	-0.120	0.263
PCO2	-0.302	<0.001*
HCO3	-0.424	<0.001*
Urea mg/dl	0.218	0.042*
Creatinine (mg/dl)	0.256	0.014*
Sodium mmol/L	-0.053	0.619
Potassium mmol/L	-0.208	0.062
Ionized Calcium mmol/L	0.210	0.056

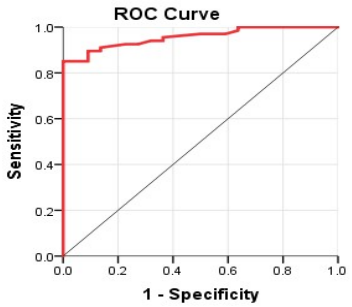

Figure 4: ROC curve of performance of serum LBP to predict Gram negative organism in stool culture in the studied group.

DISCUSSION

The high morbidity and death rates caused by gastrointestinal illnesses, which are mostly water- and food-borne, continue to be a significant concern for public health across the world, particularly in children younger than five. [11].

Early differentiation between bacterial and viral gastroenteritis is clinically important to guide appropriate antibiotic therapy and avoid unnecessary antimicrobial use, yet conventional inflammatory markers such as C-reactive protein and white blood cell count have limited sensitivity and specificity for this purpose [12].

In this study, we investigated the level of serum LBP in infants during acute gastroenteritis. Regarding our study the mean age was 17.4 ± 6.3 months with a male predominance (56.2%) and female (43.8%). This male-to-female ratio is consistent with findings reported by **Montasser et al. (2022),** who observed 58% male predominance among one hundred fifty hospitalized children with gastroenteritis at Helwan Egyptian University Hospital [13].

The mean weight of our study was 9.8±1.43kg, comparable to findings by **Seyed Motahari et al. (2022**) who reported that in their assessment of Racecadotril for the treatment of pediatric acute diarrhea, children aged from 3 to 60 months old had an average weight of 9.8 kg ± 2.4 SD in the ORS group and 9.4 kg ± 2.6 SD in the ORS+ Racecadotril group.[14].

Regarding clinical presentation, the median number of diarrhea motions was seven (range 4–15) and the median number of vomiting episodes was three (range 0–7), comparable to findings by **Abdel-Rahman et al. (2021),** who reported that 40% of hospitalized pediatric patients had six or more diarrhea episodes per day [15].

The hematological profile of the studied group revealed a mean WBC count of 12.5±4.3×10³/mm³ with relative neutrophilic predominance (69±13.1%) and an absolute neutrophilic count of 8.96±4.06×10³/mm³, findings consistent with bacterial infection. **Guo et al. (2025)** reported that WBC counts were significantly elevated in children with bacterial diarrhea compared to viral diarrhea ($p<0.05$), although WBC alone had limited discriminatory power [16].

The mean CRP level in our study was notably elevated at 41.9± 27.7 mg/dL, which is consistent with the high proportion of culture-positive bacterial gastroenteritis of 75.3% in our studied infants, comparable to **Borgnolo et al. (1996),** who showed that 77% of children with bacterial gastroenteritis had CRP levels ≥ 12 mg/dL [17].

Elsing et al. (2011) similarly documented markedly elevated CRP concentrations in bacterial compared to viral gastroenteritis (10.4±9.6 vs. 3.8±5.5 mg/dl, $p< 0.001$) [7].

Stool culture was positive in 75.3% of cases, with Enteropathogenic E. coli (EPEC) being the most isolated organism (46.1%), followed by Salmonella (14.6%) and Klebsiella (13.5%). **Zhou et al. (2018)** EPEC was similarly recognized as the predominant pathotype (50% of diarrheagenic E. coli) in children under five experiencing acute diarrhea in China[18].

On the other hand, **Khairy et al. (2020),** in a study from Upper Egypt, reported that diarrheagenic E. coli was isolated from stool samples of children under 5 years with diarrhea, with EPEC being the second most common pathotype (45.4%) and enteroaggregative E. coli (EAEC) was the predominant pathotype in 47% E. coli strains [19].

In our study, the isolation of Salmonella was in 14.6% of our cases, but a study by **Chung et al. (2017)** reported that Salmonella was the leading bacterial pathogen in 21.8% of children and was associated with fever, bloody stool, and elevated CRP levels in hospitalized children in Taiwan [20].

Klebsiella species was detected in 13.5% of studied cases similarly to a study by **Ananthan et al. (1999)** who reported that Twelve out of one hundred Indian children less than three years old with severe diarrhea tested positive for Klebsiella pneumoniae. [21].

In our study, the serum LBP levels ranged from 0.3 to 137.8 ng/ml, with a median value of 21.9 ng/ml. **Elsing et al. (2011)** found a mean LBP of 28.5±16.5µg/ml in patients with bacterial gastroenteritis and 15.2 ± 11.5µg/ml in those with viral gastroenteritis ($p <0.05$), which is in line with their current results.[7.]

A key finding of our study was the significant positive correlation between serum LBP levels

and dehydration severity ($p<0.001$), with median LBP values of 6.4, 21.8, and 39.9 ng/mL in mild, moderate, and severe dehydration, respectively. Increasing severity of dehydration in bacterial gastroenteritis likely reflects greater bacterial burden and intestinal mucosal damage, leading to augmented lipopolysaccharides (LPS) translocation, and consequently higher LBP production. Comparable to the findings by **Pavare et al. (2010),** who demonstrated a similar relationship between LBP levels and infection severity in children, reporting that both the severity of sepsis and the presence or absence of bacteremia were associated with considerably greater levels of LBP in children ($p<0.001$) and less severe sepsis ($p<0.001$), respectively.[22].

Our current study showed that serum LBP levels were significantly higher in infants with complications, especially observed in infants with shock and metabolic acidosis, compared to those without complications ($p<0.05$). This finding is consistent with the recognized role of LBP as a marker in pediatric infections.

The association between elevated LBP and shock in our study is entirely reasonable. This matched with **(Bersani et al., 2015)** who reported that shock in bacterial gastroenteritis reflects both hypovolemia from fluid losses and the systemic inflammatory response to endotoxemia, both of which would stimulate hepatic LBP synthesis [12].

Our current study showed that mean serum LBP was significantly higher in infants with positive stool culture (37.4±28.9 ng/ml) compared to those with negative culture (2.9 ±3.1 ng/ml, $p<0.001$), confirming the strong association between LBP elevation and gram-negative bacterial infection. This finding aligns with **Ubenauf et al. (2007)** who confirmed that median LBP serum concentrations were markedly elevated in children with invasive bacterial infection compared to controls (45.0 vs 8.3 µg/ml, $p < 0.001$), supporting LBP as a promising diagnostic marker of bacterial infection [23].

An important observation was the significant variation in median LBP levels among different gram-negative organisms ($p<0.001$). Klebsiella-infected infants had the highest LBP levels (73.2 ng/ml), followed by Salmonella (50.7ng/ml), while Enteropathogenic E. coli (21.9 ng/ml). This differential LBP response may be explained by differences in LPS structure and endotoxin release among gram-negative species. **Williams et al. (2018)** reported that Klebsiella species are known to cause an extensive burden of invasive infection in pediatric patients, with high rates of antimicrobial resistance, which may contribute to a more vigorous inflammatory response and higher LBP levels [24].

Hurley and Opal (2013) further showed that endotoxemia was associated with significantly increased mortality risk in gram negative bactermic patients, such as Klebsiella suggesting fundamental differences in endotoxin biology among species [25].

ROC curve analysis demonstrated excellent diagnostic performance of LBP for detecting gram-negative organisms in stool culture in the studied group. At a cut-off value of 11ng/ml, LBP yielded a sensitivity of 85% and specificity of 94.5%. **Elsing et al. (2011)** found that distinguishing bacterial from non-bacterial gastrointestinal infections using LBP at a cut-off of 14.6 µg/ml might have prevented 14% of patients from needlessly undergoing antibiotic medication. [7].

The correlation analysis revealed that LBP had a positive correlation with CRP ($r = 0.677$, $p<0.001$), WBC count ($r=0.428$, $p<0.001$), and number of diarrhea motions ($r =0.447$, $p<0.001$). The correlation between LBP and CRP is expected, as both are hepatic acute-phase reactants that rise in response to bacterial infection, via different pathways. LBP is specifically triggered by LPS from gram-negative bacteria, while hepatic CRP production responds to IL-6 stimulation and other pro-inflammatory cytokines such as IL-1 from any inflammatory process[12].

Elsing et al. (2011) reported that both LBP and CRP were significantly elevated in bacterial versus viral gastroenteritis, and they concluded that CRP and LBP were superior to IL-6 and WBC as diagnostic markers of bacterial gastrointestinal infection[7].

The significant positive correlations of serum LBP with neutrophils percentage ($p= 0.013$) and platelets ($p<0.001$), and the negative correlation with lymphocyte percentage ($p=0.011$), further support the association between LBP elevation and the systemic inflammatory response to bacterial infection.

The negative correlation between LBP and HCO_3 ($P< 0.001$) and PCO_2 ($p< 0.001$) suggests that higher LBP levels are associated with more severe metabolic acidosis, reflecting the interplay between bacterial infection severity, dehydration, and metabolic derangement. The positive correlations with urea ($p=0.042$) and creatinine ($p=0.014$) further indicate that LBP elevation parallels the degree of prerenal impairment secondary to dehydration.

The significant positive correlation between LBP and length of hospital stay (r= 0.350, p<0.001) supports the value of LBP as a marker of disease, as higher LBP levels were associated with longer hospitalization time.

Kevan et al. (2011) similarly showed that hospitalized patients with intestinal failure had a greater baseline level of LBP (27.5± 8.7 versus 13.5±9.2 µg/ml, p=0.002) compared to outpatients indicating that LBP might be an indicator of the severity of the illness. [26].

Our study has potential limitations: it was conducted at one center. the cross-sectional design with a single time-point LBP measurement could not allow for assessment of the temporal kinetics of LBP during illness, which may have provided additional prognostic information. Further multicentric studies with larger sample size are needed to establish consistent cut-off values and to assess utility of serial LBP monitoring.

CONCLUSION: Serum Lipopolysaccharide-Binding Protein (LBP) is a reliable diagnostic and prognostic biomarker for gram-negative bacterial infection in infants with acute gastroenteritis. LBP can serve as an adjunctive tool to guide for early management of bacterial gastroenteritis in hospitalized infants.

FUNDING:
No funds.

DECLARATION OF CONFLICTS OF INTERESTS

The author asserts that there are no conflicts of interest.

USE OF ARTIFICIAL INTELLIGENCE Not applicable

REFERENCES

1- **Guarino A, Lo Vecchio A, Dias JA.,** et al.,2018. Universal recommendations for the management of acute diarrhea in non-malnourished children. J Pediatr Gastro-enterol Nutr 2018; 67: 586–93.

2- **Kazi, S., Majumdar, R., & Mahajan, D.** et al., 2025. Assessment of electrolyte imbalance and its predictors in children admitted with Acute Gastroenteritis-Cross Sectional study. Indian Journal of Child Health, 12(2), 19-24. https://doi.org/10.32677/ijch.v12i2.5089

3- **World Health Organization.** (2024) Diarrheal disease [Internet]. Geneva (Switzerland); World Health Organization, 2024 [cited 2024 March 7]. Available from: http://www.who.int/en/news-room/fact sheets/detail/diarrheal- disease.

4- **Graves, N.S.** (2013): Acute gastroenteritis. Prim. Care, 40, 727–741.

5- **Fleckenstein JM, Matthew Kuhlmann F, Sheikh A.,** et al**.** 2021.Acute Bacterial Gastroenteritis. Gastroenterol Clin North Am. 2021 Jun;50(2):283-304.

6- **Akhondi H, Goldin J, Simonsen KA.**, et al. 2026.Bacterial Diarrhea. [Updated 2025 Jan 21]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK551643/

7- **Elsing, C., Ernst, S., Kayali, N., Stremmel, W. & Harenberg, S.,** et al.2011. Lipopolysaccharide binding protein, interleukin-6 and C-reactive protein in acute gastrointestinal infections: value as biomarkers to reduce unnecessary antibiotic therapy. Infection, 39**,** 327-31.

8- **He, Z., Song, Z., Meng, L., Cheng, W., Huang, F., Zheng, M.,** et al. 2021. Lipopolysaccharide-Induced Transcriptional Changes in LBP-Deficient Rat and Its Possible Implications for Liver Dysregulation during Sepsis. Journal of Immunology Research, 2021**,** 8356645.

9- **Mussap, M., Noto, A., Fravega, M. & Fanos, V**.,et al.2011. Soluble CD14 subtype presepsin (sCD14-ST) and lipopolysaccharide binding protein (LBP) in neonatal sepsis: new clinical and analytical perspectives for two old biomarkers. J Matern Fetal Neonatal Med, 24 Suppl 2**,** 12-4.

10- **Luo X, Deng J, Luo M, Yu N, Che X.**et al.,2024. Detection and characterization of bacterial and viral acute gastroenteritis among outpatient children under 5 years old in Guangzhou, China. Am J Trop Med Hyg 2024;110:809.

11- **United Nations Children's Fund (UNICEF).** Diarrhoea [Internet]. New York; UNICEF, 2024 [cited 2024 Jan 5]. Available from: https://data.unicef.org/topic/child-health/diarrhoealdisease/.

12- **Bersani, I., Auriti, C., Ronchetti, M. P., Prencipe, G., Gazzolo, D. & Dotta, A.** 2015. Use of Early Biomarkers in Neonatal Brain Damage and Sepsis: State of the Art and Future Perspectives. BioMed Research International, 2015**,** 253520.

13- **Montasser, K. A., Youssef, M. I., Ghandour, A. A. & Kamal, M.** 2022. Infection with adenovirus, rotavirus, and co-

infection among hospitalized children with gastroenteritis in an Egyptian university hospital. Journal of Medical Virology, 94**,** 4950-4958.

14- **Seyed Motahari S, Imanzadeh F, Hosseini A, Dara N, Khatami K, et al.2022** The Efficacy and Safety of Enkephalinase Inhibitor Racecadotril in Treatment of Acute Diarrhea in Children: A Randomized Clinical Trial J Compr Ped. 2022;13(2):e127104. DOI:https://doi.org/10.5812/compreped-127104

15- **Abdel-Rahman, M. E., Mathew, S., Al Thani, A. A., Ansari, K. A. & Yassine, H. M.** 2021. Clinical manifestations associated with acute viral gastroenteritis pathogens among pediatric patients in Qatar. Journal of Medical Virology, 93**,** 4794-4804.

16- **Guo, Q., Guo, H. & Xu, X.,**et al. 2025. The Value of Fecal Calprotectin Combined with Procalcitonin in the Differential Diagnosis of Bacterial and Viral Diarrhea in Children. Am J Trop Med Hyg, 112**,** 1060-1064.

17- **Borgnolo, G., Barbone, F., Guidobaldi, G. & Olivo, G.** 1996. C-reactive protein in viral and bacterial gastroenteritis in childhood. Acta Paediatr, 85**,** 670-4.

18- **Zhou, Y., Zhu, X., Hou, H., Lu, Y., Yu, J., Mao, L.,** et al. 2018. Characteristics of diarrheagenic Escherichia coli among children under 5 years of age with acute diarrhea: a hospital based study. BMC Infect Dis, 18**,** 63.

19- **Khairy, R. M. M., Fathy, Z. A., Mahrous, D. M., Mohamed, E. S. & Abdelrahim, S. S.** 2020. Prevalence, phylogeny, and antimicrobial resistance of Escherichia coli pathotypes isolated from children less than 5 years old with community acquired diarrhea in Upper Egypt. BMC Infect Dis, 20**,** 908.

20- **Chung, N., Wang, S. M., Shen, C. F., Kuo, F. C., Ho, T. S., Hsiung, C. A.,** et al. 2017. Clinical and epidemiological characteristics in hospitalized young children with acute gastroenteritis in southern Taiwan: According to major pathogens. J Microbiol Immunol Infect, 50**,** 915-922.

21- **Ananthan, Raju S, Alavandi S.,** et al.1999 Enterotoxigenicity of Klebsiella pneumoniae associated with childhood gastroenteritis in Madras, India. Jpn J Infect Dis. 1999 Feb;52(1):16-7. PMID: 10808254.

22- **Pavare, J., Grope, I., Kalnins, I. & Gardovska, D.,**et al**.** 2010. High-mobility group box-1 protein, lipopolysaccharide-binding protein, interleukin-6 and C-reactive protein in children with community acquired infections and bacteremia: a prospective study. BMC Infect Dis, 10**,** 28

23- **Ubenauf, K. M., Krueger, M., Henneke, P. & Berner, R.** 2007. Lipopolysaccharide binding protein is a potential marker for invasive bacterial infections in children. Pediatr Infect Dis J, 26**,** 159-62

24- **Williams, P. C. M., Isaacs, D. & Berkley, J. A.** 2018. Antimicrobial resistance among children in sub-Saharan Africa. Lancet Infect Dis, 18**,** e33-e44.

25- **Hurley, J. C. & Opal, S. M.** 2013. Prognostic value of endotoxemia in patients with Gram-negative bacteremia is bacterial species dependent. J Innate Immun, 5**,** 555-64.

26- **Kevan, E. N., Simmons, J. R., Kocoshis, S. A., Cohen, M. B. & Rudolph, J. A.** 2011. sTREM-1 and LBP in central venous catheter-associated bloodstream infections in pediatric intestinal failure. J Pediatr Gastroenterol Nutr, 53**,** 627-33.