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Pattern of bacteriological and biochemical profile and determinants of metabolic acidosis among under-fives with diarrheal diseases at the diarrhea treatment and training unit of the University of Calabar Teaching Hospital, Calabar, Nigeria

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ABSTRACT

Objectives: Dehydration and electrolyte derangements are major causes of morbidity and mortality in diarrhea disease. We aimed to evaluate the pattern and determinants of electrolyte derangements and isolates in a stool sample of under-fives with diarrhea at a tertiary hospital in Nigeria.

Materials and Methods: This was a prospective and cross-sectional study of 136 under-fives admitted into the diarrheal training and treatment unit who were consecutively recruited. Patients were tested for association using Pearson's Chi-square, Kruskal–Wallis' test, and logistic regression modeling.

Results: A total of 136 babies were recruited. Three of the stool sample were culture positive for non-specified *Escherichia coli*, another two grew *Entamoeba histolytica*. Almost half (n = 56/136, 41.2%) of the children had metabolic acidosis. Predictors of acidosis included severe dehydration (adjOR: 5.76, 95%CI: 1.54–21.50, P = 0.009), ≤3 months breastfeeding (AdjOR 0.39, 95%CI: 0.153–0.997, P = 0.049), and fever (adjOR 6.30, 95%CI: 1.74–22.83, P = 0.005).

Conclusion: Metabolic acidosis was common with diarrhea for which exclusive breastfeeding was protective in this study. Although few, the growth of *E. histolytica* implicates sanitary conditions and suggests the viral origin of diarrhea, hence strongly supports the introduction of rotavirus vaccine in our national routine immunization schedule while proper use of ORS may impact positively on the metabolic complication of diarrheal disease in the tropics.

Keywords: Bacteriological profile, Biochemical profile, Diarrheal disease, Children, Calabar

INTRODUCTION

Diarrheal diseases are estimated by the World Health Organization (WHO) to cause about 1.9 million deaths in under-fives, mostly in low- and middle-income countries (LMICs).[1,2] Of these deaths, 78% occur in the African and Southeast Asian regions.[1-7] Diarrhea is common in regions with poor hygiene and sanitation, coupled with limited access to safe water.[8]

Most cases of diarrheal disease in the under-fives are due to viruses. Enteroviruses and rotavirus are dominant enteric pathogens in children.[9-11] Occasionally, the diarrheal disease could be caused by bacterial organisms such as *Escherichia coli*, *Shigella*, *Campylobacter jejuni*, *Salmonella*, and *Vibrio cholerae*. Rarely, parasitic organisms such as *Entamoeba histolytica*, *giardiasis*, and *cryptosporidium* could cause diarrhea in children.[1,2,9,10,12] These organisms are transmitted feco-orally[8] and open defecation remains a major challenge in some LMICs.[13]

The common complications of diarrheal diseases are fluid loss, electrolyte imbalance, septicemia, and malnutrition.[1,14] Acidosis is a strong prognostic factor for poor outcomes in children with diarrheal disease.[15,16]

The accurate assessment of dehydration status and a high index of suspicion for electrolyte derangement among under-fives with diarrheal diseases are very central to the prevention of morbidity and mortality. The severity of dehydration can be associated with the degree of electrolyte and metabolic derangement that requires prompt care and interventions.[15,16]

Several studies documented positive stool cultures in children below the age of 5 years.[1,8,14,17] Environmental changes and genomic and immune responses of children may impact the current bacterial and biochemical pattern of diarrhea.[18]

Diarrheal diseases and their sequelae can be prevented with simple measures such as personal and environmental hygiene, water and food sanitation, and diarrhea treatment training for health workers and mothers. Furthermore, the use of oral rehydration salt solution (ORS), probiotics, zinc sulfate tablet, and timely treatment of shock, and comorbidities are major means of prevention.[1,2]

We aimed to evaluate the pattern and predictors of electrolyte derangements and one isolate in stool sample concerning dehydration of under-fives with diarrhea at a tertiary hospital in South-South Nigeria, to guide early interventions.

MATERIAL AND METHODS

Study site

This is a prospective and cross-sectional study of patients admitted into the Diarrheal Training and Treatment Unit (DTTU) of a teaching hospital in South-South Nigeria from January 1, 2016, to December 31, 2016. DTTU was inaugurated in 1995 in line with the WHO guidelines on promoting efficient diarrhea treatment. The mission of DTTU is: (1) To treat children with diarrheal disease, (2) to train their mothers/caregivers on the home management of diarrhea, and (3) for didactic training of nurses, medical students, and residents on current management of childhood diarrhea. The center's six-bed capacity DTTU is a subunit of the children's emergency room (CHER) and provides round-clock services. Activities in the DTTU are coordinated by the dedicated consultant in CHER, the Matron-in-Charge of DTTU, and six pediatric-trained nurses of different cadres. CHER and DTTU are covered by at least two seniors, four junior pediatric residents, and six house officers. Although there are seasonal variations, this DTTU admits on average, 30 patients monthly. There is evidence that in tropical areas, rotavirus diarrhea is recorded all year round, with peaks during the dry months, while bacterial diarrheas usually peak during the rainy and warmer periods.[19]

Ethical approval was obtained from the Hospital's Human Research and Ethics Committee, before the commencement of the study. The unit coordinators also permitted the study to be conducted. All under-fives admitted to DTTU with no prior administration of antibiotics or diuretics during the index illness and whose parents consented to the study were consecutively recruited.

Data collection

Patient information was entered into a data collection form which was assessed for face validity and reliability using the test-retest method.[20] The principal investigator and the resident doctors who assisted were trained in data extraction and sampling technique. Details collected include date of admission, age, sex, religion, residence, presenting complaints, drug history, home remedy, and nutritional status. The hydration status in the children was classified using the WHO criteria. Caregivers were instructed to inform the investigator once the child passes stool. Observing universal health precautions and a standard protocol for sample collection, two stool samples were collected into universal stool culture bottles (one for microscopy and the other for culture and sensitivity) and where there is visible blood stains or mucous, an attempt was made to include the site that contained blood or mucous. The stool samples were submitted within 5 min of sample collection to the laboratory for analysis using standard laboratory techniques as described by Dooki *et al*.[21] Finger prick sample was obtained for random blood sugar which was checked using a fine test glucometer machine 2014 model IGM-0017B and auto-coding test strips code C20 expiring September 4, 2017. In addition, using appropriate sample bottles, 2 ml of patient peripheral venous blood was obtained for urea/electrolytes/creatinine which was immediately sent to the hospital research laboratory for analysis using flame photometer model 420 with two channels.[6,7] All the equipments used were standardized daily before use. From the hospital laboratory reference value, the normal values were sodium: 135–145 mmol/L, potassium: 3.5–5.0 mmol/L, chloride: 98–108 mmol/L, and bicarbonate: 22–28 mmol/L. A blood sugar level below 2.2 mmol/l was suggestive of hypoglycemia.

Data analysis

Data collected were entered into an electronic data spreadsheet (Microsoft® Excel®) and exported to Stata version 16 Statistical software (Stata Corp., USA) for analyses.

A descriptive analysis of the data was presented as frequency distributions and percentages, either in tables, histograms, pie, and bar charts. Continuous variables were presented as mean and standard deviation or median and interquartile range. The association between dehydration status and electrolyte derangement was assessed using Pearson's Chi-square while an association between continuous variables and dehydration or electrolyte derangement was conducted using Kruskal–Wallis test. The univariate and multivariate regression model was conducted with metabolic acidosis (serum PH ≤7.2 or HCO_3 level below 20 mmol/l) as the outcome. Variables with $P < 0.2$ were added to the multivariate model and backward elimination methods were used to build the final model. Some variables were chosen *a priori* based on biological plausibility. The odds ratio (and 95% confidence interval) was calculated. The level of statistical significance was set at $P < 0.05$. Post-regression estimation was done. Variance inflation factor (VIF), Hosmer-Lemeshow goodness of fit test, and area under the curve of the receiver operator curve were conducted. VIF <10 does not suggest collinearity while the *P*-value of the Hosmer-Lemeshow test >0.05 shows a good fit. The weight and age of the baby were not added to the same model because there was a strong correlation between the two variables ($\alpha = 0.8365$, $P < 0.001$).

RESULTS

Patient's characteristics

A total of 136 babies were recruited. The male: female ratio was 1.4:1 (males: $n = 80/136$, 58.8% and females: 56/136, 41.2%). Most patients ($n = 112$; 82.4%) were younger than 2 years and resides in the urban area (urban: $n = 122/136$, 89.7% and rural $n = 14/136$, 10.3%).

We found that all the babies had frequent stool while a majority of them had fever ($n = 108/136$, 79.4%) and vomiting ($n = 104/136$, 76.5%). Home remedy (mainly ORS) was administered for more than three-quarters ($n = 109/136$, 79.4%) of the babies before presentation at the hospital [Table 1].

Table 1: Description of patients presenting complaints and home remedies received.

Parameter	Frequency (n=136)	Percent
Patient presenting complaint		
Fever	108	79.4
Vomiting	104	76.5
Home remedy received		
Oral rehydration salt solution (ORS)	109	80.1
Salt sugar solution (SSS)	4	2.9
Nil	23	17.0
Duration of illness before presentation (hours)		
24	45	33.1
48	38	27.9
72	16	11.8
>72	37	27.2
Source of drinking water		
Bore hole	45	33.1
Piped to home	10	7.4
Piped to compound	11	8.1
Sachet/bottled	65	47.8
Stream	4	2.9
Combination	1	0.7
Hand washing practices by caregiver before feeding		
Always no soap	5	3.7
Always with soap	33	24.3
Sometimes soap	80	58.8
Sometimes no soap	16	11.8
Never	2	1.5
Home toilet facility		
Water closet (WC)	115	84.6
VIP toilet	6	4.4
Pit toilet	14	10.3
Throw away	1	0.7
Baby defecation method		
Pampers	37	27.7
Potty	84	61.8
Free range	7	5.1
Water closet (WC)	8	5.9

Associated pre-hospital diarrheal factors

The most common sources of drinking water among patients were sachet/bottled water ($n = 65/136$, 47.8%) and only about one-quarter ($n = 33/136$, 24.3%) of the caregivers always washed their hands with soap. Water closet was available in the homes of most of them ($n = 115/136$, 84.6%) and majority ($n = 84/136$; 61.8%) of the babies defecated in potty [Table 1].

Diagnosis

Diarrheal disease with some dehydration was the most common diagnosis ($n = 98/136$, 72%) among the patients while dysentery was the diagnosis in only 9.6% ($n = 13/136$) of the patients [Figure 1].

Investigation results

In this study, stool samples from 5 (3.7%) children were culture positive, with three growths of non-specified *E. coli* and two of *E. histolytica* [Figure 2]. The antimicrobial sensitivity result of the stool samples that were growth positive showed that all the organisms were sensitive to ceftriaxone, gentamycin, ciprofloxacin, and nalidixic acid [Table 2]. Almost half ($n = 56/136$, 41.2%) of the children had acidosis while creatinine was normal in all of them.

Nearly, all (*n* = 132/136; 97.0%) the babies had normal RBS result [Figure 3].

Table 2: The antibiotic sensitivity pattern of the five stool samples that were growth positive.

S. No.	Antimicrobial	Sensitivity analysis of five growth-positive stool samples		
		Sensitive	Moderately sensitive	Resistant
1	Ampicillin			5
2	Cloxacillin			5
3	Ceftriaxone	5		
4	Cefixime			
5	Cefuroxime			
6	gentamycin	5		
7	Erythromycin			5
8	Ciprofloxacin			
9	Nalidixic acid	5		
10	Tetracycline			5
11	Cotrimoxazole	5		
12	Chloramphenicol			5

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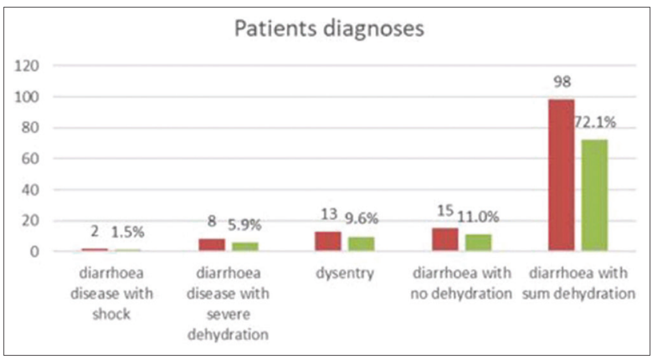

Figure 1: Frequency distribution of patient's diagnoses.

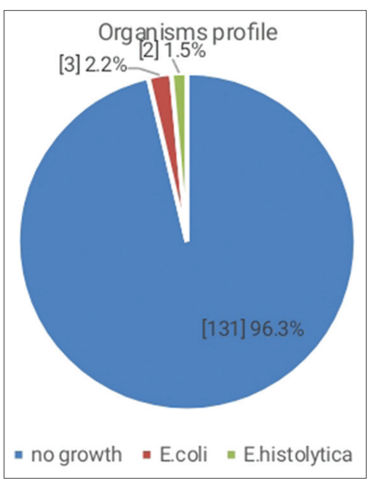

Figure 2: Pie chart of organism cultured in the patient's stool.

Association between the patient's sociodemographic and clinical characteristics with dehydration status and electrolyte derangements

There was no statistically significant association between a majority of the sociodemographic characteristics and dehydration status [Table 3].

History of vomiting (P =0.027), nutritional appearance/status of the baby (P = 0.046), pulse volume (P < 0.001), and level of consciousness (P < 0.001) had statistically significant association with dehydration status [Table 4].

From Table 5, mother's education (P = 0.001), father's education (P = 0.007), and fathers occupation ($P \leq 0.001$) had significant relationship with electrolyte derangement. Table 6 shows that history of fever (P = 0.010), breastfeeding history (P = 0.030), and hydration status (P = 0.010) had statistically significant association with electrolyte derangement.

Logistic regression of the predictors of metabolic acidosis

From Table 7, a history of breastfeeding for <3 months, history of fever, and dehydration status were associated with metabolic acidosis after univariate logistic regression modeling. However, age, weight gender, pre-hospital treatment, vomiting, and volume of stool did not have a statistically significant association with metabolic acidosis on univariate regression analysis.

After correcting for confounding variables in a multivariate analysis, dehydration status, non-exclusively breastfeeding, and history of fever were independent predictors of metabolic acidosis among our cohort of children with diarrheal disease. The odds of metabolic acidosis among children with moderate-to-severe dehydration were about 5.8 times and the odds of metabolic acidosis among children with none or mild dehydration (adjOR: 5.76, 95%CI: 1.54–21.50, P = 0.009). Children that had a history of fever had a 6-fold odd of developing metabolic acidosis as compared to children

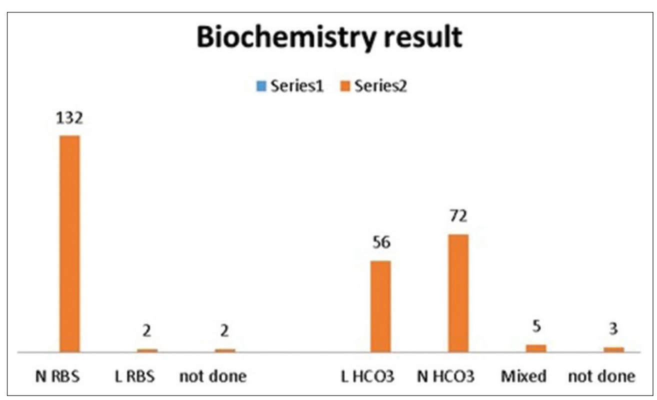

Figure 3: Pattern random blood sugar, urea, and electrolytes.

Table 3: Association between sociodemographic and dehydration status.

Characteristics	Hydration status (%)					*P*-value
	No dehydration	Mild dehydration	Moderate dehydration	Severe dehydration	Shock	
Age (median, IQR)	24 (14–28)	14 (9.5–36)	12 (9–21)	9 (5–30)	18 (18–18)	0.5831
<1 year	1 (20.0)	5 (31.3)	43 (39.1)	2 (50.0)	0 (0.0)	0.847
≥1 year	4 (80.0)	11 (68.8)	67 (60.9)	2 (50.0)	1 (100.0)	
Gender						
Male	2 (40.0)	9 (56.3)	66 (60.0)	3 (75.0)	0 (0.0)	0.609
Female	3 (60.0)	7 (43.8)	44 (40.0)	1 (25.0)	1 (1 00.0	
Weight (Kg), (median, IQR)	10 (7.2–14)	10.5 (7.6–14)	9.2 (7.8–11)	7.5 (6.8–11.8)	6.2 (6.2–6.2)	0.3632
Marital status of mothers						
Married	5 (100.0)	15 (93.8)	94 (85.5)	2 (50.0)	0 (0.0)	0.065^
Cohabiting	0 (0.0)	1 (6.3)	12 (10.9)	2 (50.0)	0 (0.0)	
Single	0 (0.0)	0 (0.0)	4 (3.6)	0 (0.0)	1 (100.0)	
Mother education						
No formal	0 (0.0)	0 (0.0)	3 (2.7)	0 (0.0)	0 (0.0)	0.404^
Primary	0 (0.0)	1 (6.3)	3 (2.7)	1 (25.0)	0 (0.0)	
Secondary	1 (20.0)	9 (56.3)	50 (45.5)	2 (50.0)	1 (100.0)	
Tertiary	4 (80.0)	6 (36.5)	54 (49.1)	1 (25.0)	0 (0.0)	
Mothers occupation						
Homemaker	0 (0.0)	2 (12.5)	28 (25.5)	0 (0.0)	0 (0.0)	0.243^
Trading	2 (40.0)	6 (37.5)	39 (35.5)	1 (25.0)	0 (0.0)	
Employee in private or government service	3 (60.0)	5 (31.3)	30 (27.3)	2 (50.0)	0 (0.0)	
Self-employed	0 (0.0)	2 (12.5)	13 (11.8)	1 (25.0)	1 (100.0)	
Farmer	0 (0.0)	1 (6.3)	0 (0.0)	0 (0.0)	0 (0.0)	
Fathers education						
Primary	0 (0.0)	1 (6.3)	4 (3.6)	0 (0.0)	0 (0.0)	0.570^
Secondary	3 (60.0)	8 (50.0)	39 (35.5)	2 (50.0)	1 (100.0)	
Tertiary	2 (40.0)	7 (43.8)	67 (60.9)	2 (50.0)	0 (0.0)	
Fathers occupation						
Self-employment	3 (60.0)	7 (43.7)	47 (42.7)	3 (75.0)	1 (100.0)	0.620
Paid employment	2 (40.0)	8 (50.0)	62 (56.4)	1 (25.0)	0 (0.0)	
Farmer	0 (0.0)	1 (6.3)	1 (0.9)	0 (0.0)	0 (0.0)	

with no history of fever (adjOR: 6.30, 95%CI: 1.74–22.83, P = 0.005). Although not reaching statistical significance, there were reduced odds of metabolic acidosis among babies who had pre-hospital oral rehydration.

The post-estimation mean VIF was 1.06 and there was no suggestion of collinearity in the final model. The area under the receiver operator characteristic curve was 75.9% and the P-value of the Hosmer and Lemeshow goodness of fit test was 0.295 which suggests that the model fits the data fit.

DISCUSSION

We evaluated the pattern and predictors of electrolyte derangements and isolates in stool samples concerning dehydration of under-fives admitted to a tertiary hospital on account of diarrheal disease over 1 year period.

In this study, more than three-quarters of patients presented with fever (79.4%) and vomiting (76.5%). In contrast, studies from Benin[22] and Vietnam[23] documented fever in 52.5% and 43.6% while vomiting occurred in 52.5%[22] and 53.8%, respectively, of their patients in addition to the diarrheal episodes. However, studies from India reported higher rates of fever (89.6%) and a lower rate of vomiting (61.8%) in comparison to our study.[24] The observed differences in the prevalence of fever and vomiting concerning diarrheal disease may represent regional variations in microbial patterns and seasonal variations. Nonetheless, our result supports a close relationship between fever, vomiting, and diarrheal disease.

Our study found that the most common home remedy offered by caregivers was mainly ORS (79.4%) which is in keeping with the 47–72.3% rate within the country,[25,26] and the most common source of drinking water was sachet/bottled water (47.8%). This finding is reassuring and in line with the WHO/UNICEF[1] recommendation. However, the ORS rate from our study was slightly lower than the reported rate of 89.1% in a study from Vietnam.[23] Efforts should be geared

Table 4: Association between clinical characteristics and dehydration status.

Characteristics	Hydration status (%)					*P*-value
	No dehydration	Mild dehydration	Moderate dehydration	Severe dehydration	Shock	
Cadre of admitting doctor						
Intern	0 (0.0)	1 (6.3)	4 (3.6)	0 (0.0)	0 (0.0)	0.832
Registrar	3 (60.0)	6 (37.5)	31 (28.2)	1 (25.0)	0 (0.0)	
Senior registrar	2 (40.0)	9 (56.3)	72 (65.5)	3 (75.0)	1 (100.0)	
Consultant	0 (0.0)	0 (0.0)	3 (2.7)	0 (0.0)	0 (0.0)	
Duration of illness (median, IQR) days	2 (1–2)	2 (1.5–5)	2 (1–4)	1.5 (1–4)	3 (3–3)	0.8397
Stool volume						
Small	2 (40.0)	4 (25.0)	29 (26.4)	0 (0.0)	0 (0.0)	0.760
Copious	3 (60.0)	12 (75.0)	81 (73.6)	4 (100.0)	1 (100.0)	
Vomiting						
Yes	2 (40.0)	10 (62.5)	89 (80.9)	3 (75.0)	1 (100.0)	0.027
No	3 (60.0)	6 (37.5)	21 (19.1)	1 (25.0)	1 (100.0)	
Fever						
Yes	4 (80.0)	16 (100.0)	83 (75.5)	4 (100.0)	1 (100.0)	0.106
No	1 (20.0)	0 (0.0)	27 (24.6)	0 (0.0)	0 (0.0)	
Pre-hospital treatment						
!ORS	3 (60.0)	13 (81.3)	87 (79.8)	4 (100.0)	1 (100.0)	0.637
^SSS	0 (0.0)	1 (6.3)	3 (2.8)	0 (0.0)	0 (0.0)	
None	2 (40.0)	2 (12.5)	19 (17.4)	0 (0.0)	0 (0.0)	
Exclusive breastfeeding						
Yes (> 6 months)						
Yes (3–6 months)	2 (40.0)	14 (87.5)	71 (65.1)	2 (50.0)	0 (0.0)	0.185
Yes (<3 months)	1 (20.0)	0 (0.0)	11 (10.1)	0 (0.0)	0 (0.0)	
None	2 (40.0)	2 (12.5)	27 (24.8)	2 (50.0)	1 (100.0)	
Baby's appearance						
Well nourished	4 (80.0)	16 (100.0)	95 (86.4)	3 (75.0)	0 (0.0)	0.046
Malnutrition	1 (20.0)	0 (0.0)	15 (13.6)	1 (25.0)	1 (25.0)	
Level of consciousness						
Conscious	2 (40.0)	13 (81.3)	30 (27.3)	0 (0.0)	0 (0.0)	< 0.001
Irritable	3 (60.0)	3 (18.6)	78 (70.9)	3 (75.0)	0 (0.0)	
Altered	0 (0.0)	0 (0.0)	2 (1.8)	1 (25.0)	1 (100.0)	
Pulse volume						
Full	5 (100.0)	15 (93.8)	37 (33.6)	1 (25.0)	0 (0.0)	< 0.001
Moderate	0 (0.0)	1 (25.0)	69 (62.3)	0 (0.0)	0 (0.0)	
Small	0 (0.0)	0 (0.0)	4 (3.6)	3 (75.0)	1 (100.0%)	
Capillary refill						
Normal	5 (100.0)	16 (100.0)	103 (93.0)	1 (25.0)	0 (0.0)	<0.001
Slow	0 (0.0)	0 (0.0)	7 (6.3)	3 (75.0)	1 (100.0)	

ORS: Oral rehydration salt solution, ^SSS: Salt sugar solution, Small volume stool: Stool volume <400 ml, Large volume: Stool volume>

to educate and sustain the high utilization rate of ORS by mothers as first aid for diarrheal diseases.

Our study revealed that only about one-quarter (n = 33, 24.3%) of the caregivers regularly washed their hands with soap before feeding their babies. Since the hand washing procedure with soap before feeding a child is among the veritable tool for reducing the incidence of diarrheal disease in children, public health interventions to increase awareness on improving hand washing practices in the community are of the essence.[23,27,28] This poor hand-washing practice among the respondents is surprising as the majority of our study participants were educated, urban dwellers.

Contrary to the 2017 report of UNICEF that Nigeria ranked high in open defecation with over 46 million Nigerians still defecating openly,[13] our study revealed that water closet was readily available in 84.6% of the patients' homes while the majority 84 (61.8%) of the babies defecated in the potty. Thus, it may be projected that a high proportion of the catchment population of the hospital had access to a good toilet facility. Nonetheless, poor hand washing practices and the use of

Table 5: Association between sociodemographic and acidosis.

Characteristics	Electrolyte derangement (%)			*P*-value
	Normal (*n*=72)	Acidosis (*n*=56)	Combination (*n*=2)	
Age (median, IQR)	14 (10–24)	12 (9–20.5)	16 (16–16)	0.6385
<1 year	25 (34.7)	23 (41.1)	0 (0.0)	0.446
≥ 1 year	47 (65.3)	33 (58.9)	2 (100.0)	
Gender				
Male	41 (56.9)	34 (60.7)	1 (50.0)	0.885^
Female	31 (43.1)	22 (39.3)	1 (50.0)	
Marital status of mothers				
Married	63 (87.5)	46 (82.1)	2 (100.0)	0.823^
Cohabiting	6 (8.3)	8 (14.3)	0 (0.0)	
Single	3 (4.2)	2 (3.6)	0 (0.0)	
Mother education				
No formal	1 (1.4)	1 (1.8)	1 (50.0)	0.001^
Primary	4 (5.6)	1 (1.8)	0 (0.0)	
Secondary	33 (45.8)	25 (44.6)	1 (50.0)	
Tertiary	34 (47.2)	29 (51.8)	0 (0.0)	
Mothers occupation				
Homemaker	15 (20.8)	13 (23.2)	1 (50.00)	0.877^
Trading	27 (37.5)	17 (30.4)	1 (50.0)	
Employee in private or government service	21 (29.2)	18 (32.1)	0 (0.0)	
Self- employed	9 (12.5)	8 (14.3)	0 (0.0)	
Fathers education				
Primary	1 (1.4)	3 (5.4)	1 (50.0)	0.007
Secondary	29 (40.3)	20 (35.7)	1 (50.0)	
Tertiary	42 (58.3)	33 (58.9)	0 (0.0)	
Fathers occupation				
Self-employed	29 (40.3)	29 (51.8)	1 (50.0)	<0.001^
Paid employment	43 (59.7)	27 (48.2)	0 (0.0)	
Farmer	0 (0.0)	0 (0.0)	1 (50.0)	

sachet water among our respondents may increase feco-oral transmission of pathogens.[8]

The majority of the children (72.1%) had mild-to-moderate dehydration which is similar to the reports by other authors.[24-26] The majority of our cohort of babies had moderate dehydration, at presentation, possibly because more than four-fifth of them had ORS before the presentation. Thus, public health interventions that promoted ORS administration at home should be enhanced to reduce the sequelae of severe dehydration.

Nearly all (n = 131/136; 96.3%), of the stool, analyzed yielded microscopic and culture-negative results. In line with the previous studies,[10,21,23,29] our result suggests that viral infection (possibly rotavirus) that was not cultured contributes hugely to the burden of diarrheal diseases among our cohort of babies. Five children that had positive stool growth were below 3 years of age and also were those with blood in the stool. The isolated organisms were unspecified *E. coli* in 3 (2.2%) patients and *E. histolytic* in 2 (1.5%). This pattern is similar to the report of other studies.[8,12,21,29] The finding of *E. histolytica* in the stool sample is not common but it has been isolated in under-fives.[11,12] The much expected *Shigella* and *Salmonella* species were not isolated in this study as in other similar studies.[23,30] Our study may just be highlighting a changing pattern in the microbial load in the stool of diarrhea patients. Future population-based studies are required to confirm if indeed there is a changing pattern of pathogens associated with diarrheal disease.

The antimicrobial sensitivity result of the stool samples that were growth positive showed that all the organisms were sensitive to ceftriaxone, gentamycin, ciprofloxacin, and nalidixic acid. This is similar to an Indian study.[24,30] Thus, the empirical use of these antibiotics in suspected bacterial diarrheal infections may be justified.

This study documented acidosis as the most common electrolyte derangement in children with diarrheal disease, and all occurred in children below 2 years. Studies[6,7,29,31] have shown that acidosis is a prognostic feature of diarrheal disease in children. Eke *et al*. reported a similar finding and also highlighted a higher association between acidosis and mortality. Our findings were lower than the reported prevalence of acidosis in Nigeria.[25,26] In contrast,

Table 6: Association between clinical characteristics and electrolyte derangement (acidosis).

Characteristics	Electrolyte derangement (%)			*P*-value
	Normal (*n*=72)	Acidosis (*n*=56)	Combination (*n*=2)	
Duration of illness (median, IQR) days	2 (1–4)	2 (1–3)	1.5 (1–2)	0.2463
Cadre of admitting doctor				
Intern	5 (6.9)	0 (0.0)	0 (0.0)	0.164
Registrar	17 (23.6)	17 (30.4)	1 (50.0)	
Senior registrar	47 (65.3)	39 (69.6)	1 (50.0)	
Consultant	3 (4.2)	0 (0.0)	0 (0.0)	
Stool volume				
Small	22 (30,6)	11 (19,6)	0 (0,0)	0.302
Copious	50 (69.4)	45 (80.4)	2 (100.0)	
Vomiting				
Yes	57 (79.2)	42 (75.0)	????	0.465
No	15 (20.8)	14 (25.0)	1 (50.0)	
Fever				
Yes	53 (73.6)	51 (91.1)	1 (50.0)	0.010*
No	19 (26.4)	5 (8.9)	1 (50.0)	
Pre-hospital treatment				
!ORS	57 (79.2)	46 (83.6)	2 (100.0)	0.880^
^SSS	3 (4.2)	1 (1.8)	0 (0.0)	
None	12 (16.7)	8 (14.6)	0 (0.0)	
Exclusive breastfeeding				
Yes (≥6 months)	21 (29.2)	20 (36.4)	0 (0.0)	0.030^
Yes (3–6 months)	29 (40.28)	14 (25.5)	2 (100.0)	
Yes (<3 months)	10 (13.89)	2 (3.6)	0 (0.0)	
None	12 (16.7)	19 (34.6)	0 (0.0)	
Hydration status				
None	2 (2.8)	3 (5.4)	0 (0.0)	0.010*
Mild	13 (18.1)	1 (1.8)	0 (0.0)	
Moderate	57 (79.2)	47 (83.9)	2 (100.0)	
Severe	0 (0.0)	4 (7.1)	0 (0.0)	
With shock	0 (0.0)	1 (1.8)	0 (0.0)	
Baby's appearance				
Well nourished	65 (90.2)	47 (83.9)	1 (50.0)	0.272
Malnutrition	6 (8.3)	9 (16.1)	1 (50.0)	
Obese	1 (1.9)	0 (0.0)	0 (0.0)	
Level of consciousness				
Conscious	28 (38.9)	13 (23.2)	0 (0.0)	
Irritable	42 (58.3)	41 (73.2)	2 (100.0)	
Altered	2 (2.9)	2 (3.6)	0 (0.0)	
Pulse volume				
Full	31 (43.1)	23 (41.1)	2 (100.0)	0.087^
Moderate	40 (55.6)	27 (48.2)	0 (0.0)	
Small	1 (1.4)	6 (10.7)	0 (0.0)	
Capillary refill				
Normal	67 (93.1)	51 (91.1)	2 (100.0)	0.842^
Slow	5 (6.9)	5 *(8.3)	0 (0.0)	

ORS: Oral rehydration salt solution, ^SSS: Salt sugar solution, small volume stool: Stool volume <400 ml, large volume: Stool volume >400 ml

hypernatremia (37.9%) was the most common electrolyte derangement as reported by researchers from Tanzania.[32]

Our study revealed that none of the babies managed for diarrhea had hypoglycemia. A similar low prevalence of hypoglycemia was previously reported.[6,26] Although hypoglycemia may not occur commonly in children with diarrheal disease, it could significantly contribute to diarrhea mortality when it occurred.[6]

The sociodemographic characteristics did not seem to have an association with the dehydration status of patients in this

Table 7: Logistic regression of the predictors of metabolic acidosis.

Variable	Univariate			Multivariate		
	Crude odds ratio	95% CI	*P*-value	Adj odds ratio	95% CI	*P*-value
Dehydration status						
Normal/mild	1.0	Referenced	Referenced	1.0	Referenced	Referenced
Moderate/severe shock	3.42	0.039	1.07–10.97	5.76	1.54–21.50	0.009
Age (months)	0.99	0.96– 1.02	0.501	0.980	0.95–1.006	0.136
≤11	1.0	Referenced	Referenced	1.00	Referenced	Referenced
12–59	0.76	0.37–1.57	0.462	0.67	0.28–1.60	0.373
History of fever						
No	1.0	Referenced	Referenced	1.00	Referenced	Referenced
Yes	3.66	1.27–10.53	0.016	6.30	1.74–22.83	0.005
Volume of stool						
Small	1.0	Referenced	Referenced	1.00	Referenced	Referenced
Copious	1.80	0.79–4.12	0.164	1.63	0.63–4.22	0.312
Gender						
Male	1.0	Referenced	Referenced	1.00	Referenced	Referenced
Female	0.86	0.42–1.74	0.668	0.96	0.42–2.23	0.933
History of exclusive breastfeeding						
None	1.0	Referenced	Referenced	1.00	Referenced	Referenced
≥3 month	0.43	0.18–0.999	0.050	0.39	0.153–0.997	0.049
<3 months	0.13	0.02–0.68	0.016	0.05	0.005–0.509	0.011
History of vomiting						
No	1.0	Referenced	Referenced	1.00	Referenced	Referenced
Yes	0.79	0.34–1.81	0.577	0.57	0.20–1.60	0.285
Home pre-hospital treatment						
None	1.00	Referenced	Referenced	1.0	Referenced	Referenced
ORS	1.21	0.46–3.21	0.701	0.70	0.21–2.31	0.561
SSS	0.50	0.04–5.70	0.577	0.51	0.03–7.68	0.629
Weight	0.93	0.82–1.05	0.22			
General appearance						
Well nourished/obese	1.0	Referenced	Referenced			
Malnutrition	2.11	0.70–6.32	0.184			

Key *Referenced, in some of the row refer to the variable item with which another is compared hence has no CI or *P*-value

study. The fact that all the patients reside in the metropolis and are likely to have similar characteristics and responses to diarrhea in their children may explain the finding.

The clinical findings of vomiting, nutritional appearance/status of the baby, pulse volume, and level of consciousness were associated significantly with dehydration status. This is in keeping with other studies[15,16] as copious vomiting, underweight, and low pulse volume are poor prognostic factors in diarrheal disease.

Concerning electrolyte derangement, the mother's education, father's education and father's occupation, fever in a patient, and breastfeeding history for <3 months, all had a significant relationship with the child's hydration status. Married parents who are empowered economically are more likely to seek and afford health care early to prevent complications. For children that were breastfed for 3 months and less, the introduction of complementary feeds increases the chances of using feeders and issues of hand hygiene in caregivers which predisposes the child to diarrhea disease and its complication. Fever as well as moderate and severe dehydration in our study cohorts were associated with metabolic acidosis, while exclusive breastfeeding (EBF) shows non-association, hence, protective against acidosis. This will definitely impact treatment outcomes positively and the practice of EBF should be strengthened through targeted interventions among women of childbearing age. Although not reaching statistical significance, there were reduced odds of metabolic acidosis among babies who had pre-hospital oral rehydration and this has clinical significance.

The limitations of this study include the inability of the laboratory to isolate viruses. Since blood culture was not done, our study might have missed the diagnosis of *Salmonella* species. Another limitation of the study may be the issue of social desirability, as the caregivers may not honestly respond to self-reported practices. Nevertheless, this study is the first in our environment to robustly evaluate and model the predictors of metabolic acidosis among under-fives with diarrheal diseases using regression modeling.

The post-regression analysis showed that the data fit the model, and the AUC of the ROC was 75% showing that the model will accurately predict metabolic acidosis on 75 out of 100 occasions. We recommend that for future studies, more variables may be included to improve the predictive value of the model. Furthermore, we avoided multicollinearity of the variables that may reduce the efficiency of our conclusion.

CONCLUSION

Diarrhea disease is a major cause of morbidity and mortality. Fluid and electrolyte derangement, especially acidosis, is an untoward complication that must be tackled by strengthening oral rehydration solution use and EBF. Isolation of *E. histolytica* in stools of children below 3 years calls for urgent and conscious efforts to ensure hygiene and the provision of safe portable water supply to homes. The low burden of bacterial isolates among our cohort suggests viral origin and, hence, strongly supports the introduction of the rotavirus vaccine in our national routine immunization schedule as its isolation is a challenge. Furthermore, the government should implement and enforce prescription control to prevent the development of drug resistance.

This study provides information about the clinical correlates of metabolic acidosis that may be a quick guide in emergency clinical practice in the tropics where laboratory results may not be available early. A larger multicenter study is, however, warranted to establish our findings.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Conflicts of interest

There are no conflicts of interest.

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