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High Prevalence of Extended-Spectrum β-Lactamase-Producing *Escherichia coli* in Faecal Samples of Children in Port Harcourt, Nigeria: Implications for Antimicrobial Stewardship

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ABSTRACT

Background: *Antimicrobial resistance (AMR) represents a major global public health threat. The emergence and spread of extended-spectrum β-lactamase (ESBL)-producing bacteria have significantly reduced the effectiveness of β-lactam antibiotics. Escherichia coli, a common commensal organism of the human gastrointestinal tract, is one of the principal producers of ESBL enzymes and may cause severe infections, particularly in children. In settings characterised by poor sanitation, contaminated water supplies, and inappropriate antibiotic use, ESBL-producing E. coli poses a serious therapeutic challenge.*

Aim: *This study investigated the prevalence of faecal carriage of ESBL-producing Escherichia coli among children in Port Harcourt, Rivers State, Nigeria.*

Methods: *Stool samples were collected from children aged 1–15 years presenting with symptoms of diarrhoea and vomiting. Samples were transported in sterile containers to the Microbiology Laboratory of Rivers State University for analysis. Isolation was performed using MacConkey agar and incubated at 37°C for 24 hours. Suspected colonies were sub-cultured to obtain pure isolates. Identification of E. coli was confirmed by colony morphology, Gram staining, and standard biochemical tests, including indole, motility, catalase, methyl red, and citrate utilisation tests. Antimicrobial susceptibility testing was carried out using the disc diffusion method with imipenem (10 µg), ofloxacin (5 µg), gentamicin (10 µg), cefepime (30 µg), ceftazidime (10 µg), cefotaxime (30 µg), and amoxicillin (30 µg). ESBL production was confirmed using disc synergy testing with ceftazidime, cefotaxime, and amoxicillin, with enhanced zones of inhibition indicating ESBL positivity.*

Conclusion: *The study highlights the presence of ESBL-producing E. coli among children in Port Harcourt, underscoring the need for continuous surveillance, rational antibiotic use, and improved hygiene practices to mitigate the spread of antimicrobial resistance.*

Keywords: *Extended-spectrum β-lactamase; Escherichia coli; Antimicrobial resistance; Faecal carriage; Paediatric diarrhoea; Antibiotic susceptibility.*

INTRODUCTION

Antimicrobial resistance (AMR) is a major global public health threat, driven in part by the emergence of extended-spectrum β-lactamases (ESBLs), which confer resistance to β-lactam antibiotics [1]. ESBL-mediated resistance in Gram-negative organisms is largely plasmid-encoded, frequently co-existing with resistance determinants to other antimicrobial classes, thereby promoting multidrug resistance and limiting therapeutic options [10]. Although initially confined to hospital settings, ESBL-producing organisms are now increasingly reported in community-acquired infections, particularly those caused by Escherichia coli. Intestinal colonisation with ESBL-producing strains is of particular concern, as it serves as a reservoir for resistance genes and may predispose individuals to subsequent invasive infections [2]. The dissemination of resistant *E. coli* across environmental reservoirs, including water sources and food products, further facilitates community spread [13].

Extended-spectrum β-lactamase-producing *E. coli* is recognised globally as a significant multidrug-resistant pathogen associated with both hospital- and community-acquired infections, especially in settings characterised by inadequate sanitation and hygiene [3]. Although E. coli traditionally serves as an indicator of faecal contamination, its clinical significance increases substantially when isolates exhibit multidrug resistance. ESBL genes are commonly plasmid-mediated, enabling horizontal gene transfer within aquatic and community environments [4]. Despite the growing global burden of ESBL-producing organisms, data on faecal carriage among children in many African settings remain limited [3]. Projections indicate that deaths attributable to drug-resistant infections could rise dramatically, with substantial economic consequences [13]. In the WHO African region, limited surveillance has hindered accurate assessment of resistance patterns, although high levels of AMR, including resistance in *E. coli*, have been reported [12].

Children are particularly vulnerable to enteric infections associated with poor sanitation and contaminated water. Infections caused by ESBL-producing *E. coli* may be difficult to treat and are associated with adverse clinical outcomes. In view of the increasing burden of AMR and limited regional data, this study aimed to determine the prevalence of faecal carriage of ESBL-producing *Escherichia coli* among children in Port Harcourt, Nigeria, and to evaluate associated risk factors and antimicrobial susceptibility patterns [3].

MATERIALS AND METHODS

Study Design and Setting

This hospital-based cross-sectional study was conducted to determine the prevalence of *Escherichia coli* and extended-spectrum β-lactamase (ESBL) production among children presenting with diarrhoea. The study was carried out at Rivers State University Teaching Hospital (RSUTH), Port Harcourt, Nigeria. Port Harcourt, located in the Niger Delta region along the Bonny River, has an estimated population of 1,148,665. RSUTH is a government-owned tertiary healthcare institution with 375 licensed beds and comprehensive clinical departments serving as a major referral centre in the region.

Study Population and Sampling

The study included children aged 1–15 years presenting with diarrhoea at RSUTH and Spring Rose Hospital, Port Harcourt. A total of 140 participants were recruited using a convenient sampling method, comparable to the sample size reported by Ogefere et al. (2016) in a similar Nigerian setting.

Inclusion Criteria

- Children aged 1–15 years presenting with diarrhoea.
- Parental or guardian consent obtained.

Exclusion Criteria

- Lack of parental or guardian consent.
- Antibiotic use within two weeks before sample collection.

Ethical Considerations

Ethical approval was obtained from the Research and Ethics Committee of Rivers State University Teaching Hospital. The study objectives and procedures were explained to parents or guardians, and informed oral consent was obtained before enrolment. Confidentiality was maintained throughout the study.

Specimen Collection and Processing

Approximately 1 g of freshly passed stool was collected into sterile screw-capped containers, transported in an icebox within one hour, and processed immediately according to standard operating procedures. Stool samples were inoculated onto MacConkey agar and incubated aerobically at 37°C for 24 hours. Presumptive *E. coli* colonies were subcultured on Nutrient agar for purification. Identification was based on colony morphology (bright pink lactose-fermenting colonies), Gram staining, and conventional biochemical tests including indole, motility, catalase, methyl red, and citrate utilisation tests.

Antimicrobial Susceptibility Testing

Antimicrobial susceptibility testing was performed using the Kirby–Bauer disc diffusion method on Mueller–Hinton agar in accordance with Clinical and Laboratory Standards Institute (CLSI) guidelines [5-6]. A 0.5 McFarland standard suspension was prepared and inoculated onto Mueller–Hinton agar plates. The following antibiotic discs were applied: cefotaxime (30 µg), ceftazidime (10 µg), gentamicin (10 µg), ofloxacin, cefepime (30 µg), imipenem, and amoxicillin (30 µg). Plates were incubated at 37°C for 24 hours, and zones of inhibition were measured and interpreted according to CLSI breakpoints. Isolates resistant to two or more antimicrobial classes were classified as multidrug-resistant (MDR).

Phenotypic Detection of ESBL

ESBL production was confirmed using the double-disc synergy method. Standardised bacterial suspensions were inoculated onto Mueller–Hinton agar plates, and discs of ceftazidime (30 µg), cefotaxime (30 µg), and amoxicillin (30 µg) were applied. After incubation at 37°C for 24 hours, an increase of 2–5 mm in the zone of inhibition for amoxicillin relative to ceftazidime and cefotaxime was interpreted as indicative of ESBL production.

Statistical Analysis

Data were summarized using descriptive statistics and expressed as mean ± standard deviation where appropriate. Statistical analyses were performed using GraphPad Prism version 9 (San Diego, CA, USA). An unpaired t-test was used for comparisons where applicable, and a two-tailed p-value < 0.05 was considered statistically significant at the 95% confidence interval.

Result

4.1 Sociodemographic Characteristics

A total of 140 children aged between 1 and 8 years were enrolled in this study. The mean age of participants was 3.34 years. The largest proportion of subjects fell within the 2–3-year age group, accounting for 32.9% of the study population. One-year-old children constituted 24.3%, while those aged 4–5 years represented 23.6% of participants. Children older than 5 years comprised the smallest proportion of the sample (19.3%). With respect to gender distribution, females slightly predominated, representing 73 participants (52.1%), whereas males accounted for 67 participants (47.9%). Regarding educational status, the majority of children were enrolled in daycare centres (45%). A further 32.1% were attending primary school, while 22.9% were in nursery school. In terms of school ownership, most participants (75%) were enrolled in public institutions, whereas 25% attended private schools.

The detailed distribution of sociodemographic variables is presented in Table 4.1.

Table 4.1: Sociodemographic Information of the Subjects

Variable	Frequency (N)	Percentage (%)
Age		
1	34	24.3
02-Mar	46	32.9
04-May	33	23.6
. >5	27	19.3
Total	140	100
Mean	*3.34*	
Gender		
Male	67	47.9
Female	1	52.1
Total	140	100
Level in School Daycare	63	45
Nursery	32	22.9
Primary	45	32.1
Total	140	100
Type of School		
Public	105	75
Private	35	25
Total	140	100

4.2 Risk Factors for *Escherichia coli* Infection

Information on potential risk factors for *Escherichia coli* infection was obtained from parents or guardians using a structured questionnaire. Self-medication by parents or guardians was the most frequently reported source of antibiotic use (34.3%), followed by prescriptions from chemists (24.3%). Only 23.6% of participants received antibiotics following consultation with a medical doctor, while prescriptions from pharmacists were least common (17.9%). A history of hospital admission within the preceding six months was reported in 37.9% of participants, whereas 62.1% had not been hospitalised during this period. Most children (60.7%) used shared public toilet facilities, and 70.7% were not reported to practise regular handwashing. Regarding nutrition, homemade food was the predominant source (54.3%), followed by breast milk (26.4%) and dairy products (19.3%). Tap water was the main source of drinking water (55.7%), followed by sachet water (30%) and bottled water (14.3%). The distribution of assessed risk factors is summarised in Table 4.2.

Table 4.2: Risk Factors for E. coli Infection

Variable	Frequency (N)	Percentage (%)
Source of Prescription		
Parent (Self-Medication)	48	34.3
Chemist	34	24.3
Pharmacist	25	17.9
Doctor	33	23.6
Total	140	100
Hospital Admission (< 6 months)		
Yes	53	37.9
No	87	62.1
Total	140	100
Shared Public Toilet		
Yes	85	60.7
No	55	39.3
Total	140	100
Regular Hand washing		
Yes	41	29.3
No	99	70.7
Total	140	100
Type of Nutrition		
Breast milk	37	26.4
Dairy Food	27	19.3
Homemade food	76	54.3
Total	Total	100
Source of Water		
Tap Water	78	55.7
Sachet Water	42	30
Bottled Water	20	14.3
Total	140	100

4.3 Distribution of *Escherichia coli* According to Sociodemographic Characteristics

All 140 stool samples were analysed for *Escherichia coli*, yielding 50 isolates and an overall prevalence of 35.7%. The highest age-specific prevalence was observed among children aged 2–3 years (12.9%), followed by one-year-olds (10%). Participants aged 4–5 years and those older than 5 years each accounted for 6.4% of cases. These differences were not statistically significant ($p > 0.05$). The prevalence was 17.1% among males and 18.6% among females, with no significant gender difference ($p > 0.05$). Children attending daycare centres had the highest prevalence (18.6%), while those in nursery schools had the lowest (7.1%). A higher proportion of isolates was recorded among children in public schools (25%) compared with private schools (10.7%); however, neither educational level nor school type was significantly associated with infection ($p > 0.05$). Details are presented in Table 4.3.

Table 4.3: Distribution of E. coli based on the Sociodemographic Information of the Subjects

Variable	Positive	Negative	Total	X^2	Df	p-value
	{%}	{%}	{%}			
Age						
	14 (10)	20 (14.3)	34 (24.3)	1.767	3	0.6222
02-Mar	18 (12.9)	28 (20)	46 (32.9)			
04-May	9 (6.4)	24 (17.l)	33 (23.5)			
>5	9 (6.4)	18 (12.9)	27 (19.3)			
Total	50 (35.7)	90 (64.3)	140 (100)			
Gender						
Male	24 (17.1)	43 (30.7)	67 (47.8)	0.0006361	1	0.9799
Female	26 (18.6)	47 (33.6)	73 (52.2)			
Total	50 (35.7)	90 (64.3)	140 (100)			
Level in School						
Daycare	26 (18.6)	37 (26.4)	63 (45)	1.54	2	0.463
Nursery	10 (7.1)	22 (15.7)	32 (22.8)			
Primary	14 (10)	31 (22.1)	45 (32.1)			
Total	50 (35.7)	90 (64.3)	140 (100)			
Type of School						
Public	35 (25)	70 (50)	105 (75)	1.037	1	0.3085
Private	15 (10.7)	20 (14.3)	35 (25)			..
Total	50 (35.7)	90 (64.3)	140 (100)			

4.4 Distribution of *Escherichia coli* According to Identified Risk Factors

The overall prevalence of *Escherichia coli* infection (35.7%) was analysed in relation to selected behavioural and environmental risk factors. The highest prevalence was observed among children whose antibiotics were obtained through parental self-medication (11.4%), followed by prescriptions from medical doctors (8.4%). Those receiving antibiotics from chemists or pharmacists each accounted for 7.9%. These differences were not statistically significant ($p > 0.05$).

Although equal proportions (17.9%) were observed among children with and without recent hospital admission, hospitalization within the preceding six months was significantly associated with infection ($p < 0.05$). A higher prevalence was noted among children who used shared public toilets (20.7%) compared with those who did not (15%). Similarly, infection was more common among those not practising regular handwashing, whereas 13.6% prevalence was observed among children who maintained regular hand hygiene. These associations were not statistically significant ($p > 0.05$). Homemade food was associated with the highest prevalence (20.7%), followed by breast milk (10%) and dairy products (7%). Tap water users demonstrated the highest prevalence (23.6%), followed by sachet water (7.1%) and bottled water (5%). Except for recent hospital admission, no significant associations were identified ($p > 0.05$). Detailed findings are presented in Table 4.4.

Table 4.4: Distribution of E. coli Based on Risk Factors for Infection (n = 140)

Variable	Positive n (%)	Negative n (%)	Total n (%)	χ^2	df	p-value
Source of Prescription				1.039	3	0.7917
Parent (Self-medication)	16 (11.4)	32 (22.9)	48 (34.3)			
Chemist	11 (7.9)	23 (16.4)	34 (24.3)			
Pharmacist	11 (7.9)	14 (10.0)	25 (17.9)			
Doctor	12 (8.6)	21 (15.0)	33 (23.6)			
Total	50 (35.7)	90 (64.3)	140 (100)			

Table: Distribution of E. coli Based on Selected Risk Factors (n = 140)

Variable	Category	Positive n (%)	Negative n (%)	Total n (%)	χ^2	df	p-value
Hospital Admission (<6 months)					4.875	1	0.0273*
	Yes	25 (17.9)	28 (20.0)	53 (37.9)			
	No	25 (17.9)	62 (44.3)	87 (62.1)			
	Total	50 (35.7)	90 (64.3)	140 (100)			
Shared Public Toilet					0.2402	1	0.6240
	Yes	29 (20.7)	56 (40.0)	85 (60.7)			
	No	21 (15.0)	34 (24.3)	55 (39.3)			
	Total	50 (35.7)	90 (64.3)	140 (100)			
Regular Handwashing					2.852	1	0.0913
	Yes	19 (13.6)	22 (15.7)	41 (29.3)			
	No	31 (22.1)	68 (48.6)	99 (70.7)			
	Total	50 (35.7)	90 (64.3)	140 (100)			
Type of Nutrition					1.397	2	0.4973
	Breast milk	14 (10.0)	23 (16.4)	37 (26.4)			
	Dairy food	7 (5.0)	20 (14.3)	27 (19.3)			
	Homemade food	29 (20.7)	47 (33.6)	76 (54.3)			
	Total	50 (35.7)	90 (64.3)	140 (100)			
Source of Water					4.074	2	0.1304
	Tap water	33 (23.6)	45 (32.1)	78 (55.7)			
	Sachet water	10 (7.1)	32 (22.9)	42 (30.0)			
	Bottled water	7 (5.0)	13 (9.3)	20 (14.3)			
	Total	50 (35.7)	90 (64.3)	140 (100)			

4.5 Antimicrobial Susceptibility Profile and Extended-Spectrum β-Lactamase Production of *Escherichia coli* Isolates

Fifty confirmed *Escherichia coli* isolates were tested against seven antibiotics: imipenem (10 µg), ofloxacin (5 µg), gentamicin (10 µg), cefepime (30 µg), ceftazidime (10 µg), cefotaxime (30 µg), and amoxicillin (30 µg). All isolates were susceptible to imipenem (100%). Resistance was highest to ofloxacin (60%), followed by gentamicin and ceftazidime (32% each). Resistance rates to cefepime and cefotaxime were 24% each, while only 8% of isolates were resistant to amoxicillin (92% susceptibility). Overall, imipenem showed the greatest activity, whereas ofloxacin demonstrated the lowest susceptibility. Multidrug resistance, defined as resistance to more than two antimicrobial classes, was identified in 8 isolates (16%). Phenotypic testing confirmed ESBL production in 28 isolates (56%), while 22 isolates (44%) were non-ESBL producers.

Detailed susceptibility patterns and ESBL distribution are presented in Table 4.5.

Table 4.5: Antimicrobial Susceptibility Pattern and Extended P-lactamase Production of Escherichia coli Isolates from the Subjects

		Sensitive (%)	Resistant (0fo)
Imipenem 10µg (IMI)	Carbapenem	50 (100)	0 (0)
(< 19 mm = R; 2:22 mm = S)			
Ofloxacin 5µg (OFX)	Fluoroquinolone	20 (40)	30 (60)
(< 22 mm = R; 2:24 mm= S)			
Gentamicin 10µg (GEN)	Aminoglycoside	34 (68)	16 (32)
(< 17 mm = R; 2:17 mm = S)			
Cefepime 30µg (FEP)	4th Generation	38 (76)	12 (24)
(< 19 mm= R; 2:19 mm= S)	Cephalosporin		
Ceftazidime 10µg (CAZ)	3rd Generation	34 (68)	16 (32)
(<19 mm = R; 2:22 mm = S)	Cephalosporin		
Cefotaxime 30µg (CTX)	3rd Generation	38 (76)	12 (24)

(< 17 mm = R; 2:20 mm = S)	Cephalosporin		
Amoxicillin30µg (AMC) (< 19 mm = R; 2: 19 mm = S)	P-lactam and P-lactamase inhibitor	46 (92)	4 (8)
Multidrug Resistance (MDR)		Non-MDR	MDR(%)
		(%)	
		42 (84)	8 (16)
Extended P-lactamase (ESBL) Production		Non-ESBL	ESBL (•!.)
		(%)	
		22 (44)	28 (56)

Antibiotics Class E. coli Isolates (N= 50)

4.6 Prevalence of ESBL-Producing *Escherichia coli* According to Sociodemographic Characteristics

Among the 50 confirmed *Escherichia coli* isolates, 28 (56%) were identified as extended-spectrum β-lactamase (ESBL) producers using the double-disc synergy test. Age-specific analysis showed higher proportions among children aged 1 year and 2–3 years (18% each), followed by those aged 4–5 years (12%) and those older than 5 years (8%). ESBL-producing isolates were more frequent among females (38%) than males (18%); however, these differences were not statistically significant ($p > 0.05$). With respect to educational level, the highest proportion was observed among children in primary school (57.1%), followed by daycare (28%) and nursery school (7.1%). A greater proportion of ESBL-producing isolates was recorded among children attending public schools (36%) compared with private schools (20%). No significant associations were identified between ESBL production and sociodemographic variables ($p > 0.05$). Detailed findings are presented in Table 4.6.

Table 4.6: ESBL-producing E. coli Prevalence and Sociodemographic Information of the Subjects

p-value Age	Variable (%)	ESBL (%)	Non-ESBL (%)	Total	'1.2	Df
1	9 (18)	5 (10)	14 (28)	1.556	3	0.6693
02-Mar	9 (18)	9 (18)	18 (36)			
04-May	6 (12)	3 (6)	9 (18)			
>5	4 (8)	5 (10)	9 (18)			
Total	28 (56)	22 (44)	50 (100)			
Gender						
Male	9 (18)	15 (30)	24 {48}	6.411	1	0.0113*
Female	19 (38)	7 (14)	26 (52)			
Total	28 (56)	22 (44)	50 (100)			
Level in School						
Daycare	14 (28)	12 (24)	26 (52)	0.1213	2	0.9411
Nursery	6 (12)	4 (8)	10 (20)			
Primary	8 (57.1)	6 (12)	14 (28)			
Total	28 (56)	22 (44)	50 (100)			
Type of School						
Public	18 (36)	17 (34)	35 (70)	0.9895	1	0.3199
Private	10 (20)	5 (10)	15 (30)			
Total	28 (56)	22 (44)	50 (100)			

**Statistically significance p < 0.05*

4.7 Prevalence of ESBL-Producing *Escherichia coli* in Relation to Identified Risk Factors

The overall prevalence of ESBL-producing *Escherichia coli* (56%) was examined in relation to selected behavioural and environmental risk factors. Higher proportions of ESBL-producing isolates (16% each) were observed among children receiving antibiotics through parental self-medication, chemists, and medical doctors, while the lowest proportion (8%) was recorded among those obtaining prescriptions from pharmacists. A greater prevalence was also noted among children with recent hospital admission (32%) compared with those without (24%). Children using shared public toilets (32%) and those not practising regular handwashing (36%) demonstrated higher proportions of ESBL-producing isolates than their counterparts (22% and 20%, respectively). Similarly, higher prevalence was observed among children consuming homemade food (30%) and tap water (36%), compared with other nutritional and water sources. Despite these observed differences, none of the associations between ESBL production and the assessed risk factors were statistically significant ($p > 0.05$). Detailed results are presented in Table 4.7.

Table 4.7: ESBL-Producing E. coli Prevalence and Risk Factors for Infection

Variable	Positive (%)	Negative (%)	Total (%)	'1.2	Df	p-value
Source of Prescription Parent (Self-Medication)	8 (16)	8 (16)	16 (32)	3.758	3	0.2888
Chemist	8 (16)	3 (6)	I I (22)			
Pharmacist	4 (8)	7 (I4)	I I (22)			
Doctor	8 (16)	4 (8)	I2 (24)			
Total	28 (56)	22 (44)	50 (100)			

Hospital Admission (< 6 months)						
Yes	16 (32)	9 (18)	25 (50)	1.299	0.2545	
No	12 (24)	13 (26)	25 (50)			
Total	28 (56)	22 (44)	50 (100)			
Shared Public Toilet						
Yes	17 (34)	12 (24)	29 (58)	0.1925	1	0.6609
No	11 (22)	10 (20)	21 (42)			
Total	28 (56)	22 (44)	50 (100)			
Regular Handwashing						
Yes	10 (20)	9 (18)	19 (38)	0.1411	1	0.7072
No	18 (36)	13 (26)	31 (62)			
Total	28 (56)	22 (44)	50 (100)			
Type of Nutrition: Breast milk	9 (18)	5 (10)	14 (28)	0.609	2	0.7375
Dairy Food	4 (8)	3 (6)	7 (14)			
Homemade food	15 (30)	14 (28)	29 (58)			
Total	28 (56)	22 (44)	50 (100)			
Source of Water						
Tap Water	18 (36)	15 (30)	33 (66)	1.315	2	0.5183
Sachet Water	7 (14)	3 (6)	10 (20)			
Bottled Water	3 (6)	4 (8)	7 (14)			
Total	28 (56)	22 (44)	50 (100)			

Discussion

Multiple pathotypes of Escherichia coli have been consistently implicated in infantile diarrhoea across various regions of Nigeria[10-15]. In the present study, *E. coli* was isolated in 35.7% of children presenting with diarrhoeal symptoms, underscoring its continued importance as a significant enteric pathogen in paediatric populations. This prevalence is comparable with previously reported data from South-Eastern Nigeria, where a rate of 44.74% was documented [16]. However, marked regional variability exists, with prevalence rates of 18.4% and 60.3% reported in Northern and South-Western Nigeria, respectively [17-18]. Such disparities may reflect differences in environmental sanitation, socio-economic status, antibiotic consumption patterns, healthcare accessibility, and methodological approaches across studies. Furthermore, the epidemiology of diarrhoeagenic *E. coli* is known to vary according to geographical location, temporal trends, and population dynamics [19], indicating that resistance and infection patterns remain fluid and context-dependent. In this investigation, sociodemographic variables, including age, gender, level of schooling, and type of school attended, were not significantly associated with *E. coli* infection ($p > 0.05$). These findings are consistent with those of [20], who similarly reported no statistically significant relationship between demographic characteristics and *E. coli* prevalence among children. [21-23] identified male gender and increasing age as significant risk factors in a Turkish cohort. The discrepancy may be attributable to differences in study populations, environmental exposures, and healthcare systems, particularly as the Turkish study was not restricted to paediatric participants. The absence of demographic associations in the present study may suggest widespread exposure to *E. coli* within the study setting, reducing measurable differences between subgroups.

Evaluation of behavioural and environmental risk factors revealed no statistically significant associations between *E. coli* infection and source of antibiotic prescription, use of shared public toilet facilities, handwashing practices, nutritional source, or drinking water source ($p > 0.05$). These observations align with findings reported by [24] in South-Eastern Nigeria. However, hospital admission within the preceding six months was significantly associated with infection ($p < 0.05$), with 47% of hospitalised children yielding *E. coli* isolates.

This finding corroborates the report by [25], who similarly identified recent hospitalisation as a significant risk factor. Healthcare environments are well recognised as reservoirs for resistant organisms due to selective antibiotic pressure, invasive procedures, and close patient interaction. Consequently, nosocomial acquisition and subsequent colonisation may contribute to the observed association. Nevertheless, this contrasts with another Nigerian study reporting a lower prevalence (6.89%) of Enterobacteriaceae among recently hospitalised individuals [26], suggesting that institutional infection control practices and antimicrobial stewardship policies may influence transmission dynamics.

Antimicrobial susceptibility testing demonstrated complete sensitivity to imipenem (100%), followed by high susceptibility to amoxicillin/clavulanic acid (92%). The preserved efficacy of imipenem is consistent with findings by [27] reinforcing the continued effectiveness of carbapenems against resistant isolates. However, carbapenems are considered last-line therapeutic agents and should be reserved for severe or life-threatening infections. Inappropriate or excessive use may accelerate the emergence of carbapenem-resistant organisms, which would severely limit future treatment options. Conversely, [28] identified ceftazidime and cefixime as the most active agents against ESBL-producing *E. coli*, a discrepancy that may be explained by the absence of carbapenems in their antimicrobial panel and potential regional variations in resistance profiles.

It is well established that ESBL-producing organisms exhibit intrinsic resistance to third-generation cephalosporins, including ceftazidime and cefixime, potentially resulting in therapeutic failure despite apparent in vitro susceptibility (Paterson and Bonomo, 2005). Moreover, ESBL-mediated resistance may not always be readily detectable by routine disc or dilution methods, yet may be associated with adverse clinical outcomes [7; 29-30]. This phenomenon may partly explain discrepancies between laboratory susceptibility results and clinical response. In many Nigerian laboratories, confirmatory ESBL testing is not routinely performed, increasing the risk of underestimating resistance patterns. [31] reported a 64% prevalence of multidrug-resistant *E. coli* in a comparable setting, suggesting that the true burden of resistance may be higher than commonly reported.

Environmental antibiotic exposure in agriculture and animal husbandry may further sustain selective pressure and facilitate resistance dissemination.

The prevalence of ESBL production in this study was 56%, indicating a substantial burden among the paediatric population. The emergence of ESBL-producing strains has been closely linked to the widespread use and misuse of third-generation cephalosporins [32]. In Nigeria, antibiotics are frequently obtainable without prescription, and regulatory enforcement remains limited [34-36]. Comparative data from other developing countries demonstrate considerable variability in ESBL prevalence, including 21.1% in Nigeria [38] 31.1% in Egypt [2] 48.7% in Iraq [4] and 64.3% in India [37]. These variations likely reflect differences in antibiotic regulation, sanitation infrastructure, surveillance capacity, and healthcare access. Both India and Nigeria bear significant burdens of childhood diarrhoeal mortality, with India reporting over 350,000 deaths annually among children under five years (UNICEF, 2009). The presence of ESBL-producing strains may therefore contribute to increased disease severity, prolonged illness, and poorer clinical outcomes in such high-burden settings.

No statistically significant association was observed between ESBL production and age, level of schooling, or school type. This contrasts with findings by [39] who identified associations with water source, hygiene practices, and educational stage. Other studies have also reported demographic and clinical factors as predictors of colonisation with drug-resistant Enterobacteriaceae [40-47]. The absence of significant associations in the present study may indicate that resistant strains are widely distributed within the community, thereby diminishing discernible subgroup differences.

Environmental considerations are also of importance. Port Harcourt is characterised by extensive waterways, some of which serve as domestic water sources. International investigations have identified ESBL-producing *E. coli* in river systems in the Netherlands (17.1%) and South Korea (60%) [48;11;49-55]. In settings where wastewater management and sewage treatment are inadequate, aquatic environments may function as reservoirs and transmission pathways for resistant bacteria. Consequently, contaminated water may facilitate household and community spread through domestic use, food preparation, and direct contact. Further molecular and environmental epidemiological studies are warranted to elucidate transmission pathways within this region, the present study demonstrates a considerable prevalence of ESBL-producing *Escherichia coli* among children with diarrhoea in Port Harcourt. These findings underscore the urgent need for strengthened antimicrobial stewardship programmes, routine ESBL detection in clinical laboratories, enhanced infection prevention measures, and sustained surveillance efforts to mitigate the spread of antimicrobial resistance in both healthcare and community settings.

Conclusion and Recommendations

This study demonstrated that *Escherichia coli* remains a significant cause of diarrhoeal infection among children in Port Harcourt, with an overall prevalence of 35.7%. Recent hospital admission was identified as a significant risk factor, suggesting that healthcare exposure may facilitate colonisation or acquisition of resistant strains. Antimicrobial susceptibility testing showed complete sensitivity to imipenem, whereas ofloxacin exhibited the lowest activity.

Notably, 16% of isolates were multidrug resistant and 56% were confirmed as extended-spectrum β-lactamase (ESBL) producers, highlighting a substantial burden of antimicrobial resistance within the paediatric population.

These findings underscore the urgent need for strengthened infection prevention and control measures, particularly in hospital settings, alongside robust antimicrobial stewardship programmes to promote rational antibiotic use. Enhanced laboratory capacity for routine ESBL detection, stricter regulation of antibiotic sales, and sustained epidemiological surveillance are essential to limit further dissemination. Additionally, larger and methodologically rigorous studies, including molecular characterisation of resistance mechanisms, are warranted to inform empirical treatment guidelines and public health policy.

Limitations

This study has several limitations that should be considered when interpreting the findings. The use of a convenient sampling method with a total of 140 participants may limit the generalisability of the results to the broader paediatric population. A larger, statistically determined sample size and multi-centre recruitment would enhance representativeness and improve the precision of prevalence estimates. In addition, the range of sociodemographic and behavioural variables assessed was limited. Inclusion of more detailed information on parental education, household socio-economic status, sanitation practices, water treatment methods, prior healthcare exposure, and patterns of antibiotic use would allow for a more comprehensive evaluation of risk factors associated with infection, multidrug resistance (MDR), and ESBL production. Furthermore, antimicrobial susceptibility testing was restricted to seven antibiotics, representing a limited number of antimicrobial classes. A broader antimicrobial panel would provide a more complete assessment of resistance patterns and multidrug resistance indices. Molecular characterisation of resistance mechanisms was also not performed; identification of specific ESBL genes and other resistance determinants would strengthen understanding of transmission dynamics and local epidemiology. Addressing these methodological limitations in future studies would enhance the robustness of evidence and support more informed clinical and public health decision-making.

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