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Prevalence of paediatric diarrhoea in Arba minch government health institutions, Southern Ethiopia and associated factors

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Infectious diarrhoea is one of the leading causes of paediatric morbidity and mortality in developing countries like Ethiopia; several factors contribute to the worsening of condition. This study was aimed to determine the prevalence and associated factors of enteropathogens, and antimicrobial susceptibility patterns of enterobacteria among paediatric patients attending four selected government health institutions in Arba Minch, southern Ethiopia. The study materials were stool samples collected from 367 paediatric patients with acute diarrhoea, which were then inoculated onto MacConkey agar, xylose lysine deoxycholate agar, and Campylobacter selective media for the isolation of enteric bacteria. Catalase, oxidase, indole, hydrogen sulfide, citrate, urease, and carbohydrate fermentation tests were performed for the phenotypic identification of the recovered isolates. The antibiotic susceptibilities of enterobacteria were determined via the Kirby-Bauer disc diffusion method. The wet mount and formol-ether concentration techniques were also used to identify enteroparasites. Descriptive and inferential statistical analyses were done using SPSS, and P-values ≤ 0.05 were considered statistically significant. Among 367 paediatric patients, 39.8% (*n* = 146) were tested positive for any one of the entero-pathogens, constituting 37.6% (*n* = 138) entero-parasites and the rest 2.2% (*n* = 8) corresponded to enterobacteria; *Giardia lamblia* (17.9%, *n* = 66) and *Entamoeba histolytica* (14.4%, *n* = 42) were predominant among the former; *Shigella dysenteriae* (1.1%, *n* = 4), followed by Salmonella Typhimurium and *Campylobacter jejuni/coli* (0.55%, *n* = 2 each), were the dominant bacteria. Invariably, all isolates were 100% susceptible to ciprofloxacin. The occurrence of bloody diarrhoea [(AOR = 3.01, 95% CI (1.65–5.48)] and having illiterate parents [(AOR = 5.46, 95% CI (1.79–16.66)] were found to be statistically associated with the enteric infection. More than a fourth of the paediatric patients in the cohort were affected by enteropathogens; intestinal protozoans were the predominant group, highlighting a significant health concern that demands immediate attention. Besides, edifying the parents of paediatric patients about personal hygiene and sanitation practices would be the most important intervention strategy to emphasise.

Keywords Arba minch, Paediatrics, Diarrhoea, Enteropathogens, Enteroparasites

Diarrhoea is a major contributor to morbidity and mortality in paediatrics worldwide, and it is one of the top three health challenges[1]. Observations from studies so far done revealed that recurrent episodes of diarrheal infections in paediatrics, particularly without catch-up growth, can lead to growth faltering and stunting. These can impact cognitive development, reduce schooling, lower productivity, and increase the risk of malnutrition

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and metabolic disorders[2]. The stunting also raises the risk of mortality from other infectious diseases like malaria, measles, and pneumonia[2,3].

According to the World Health Organization (WHO), 1.7 billion cases of paediatric diarrhoea are reported globally, causing the death of around half a million every year[4]. Sub-Saharan Africa and South Asia are known for the major proportion of morbidity and mortality in this context[1]. Ethiopia has the second highest burden of diarrhoea in Africa, causing 12% of paediatric mortality, surpassing the combined annual deaths from malaria, HIV/AIDS, and measles[5], and the overall prevalence of diarrhoea among children is 12% in the country[6].

The most important cause of paediatric diarrhoea is infections of diverse etiologies, inclusive of viral, bacterial and parasitic enteropathogens. A Global Enteric Multi-center study revealed that the prominent etiology causing moderate-to-severe diarrhoea in paediatrics were rotavirus, *Cryptosporidium*, *Shigella*, and enterotoxigenic *Escherichia coli*[7]. Salmonella and *Shigella* infections remain significant public health concerns worldwide and are now the leading bacterial infections among paediatrics[8,9]. Shigellosis is one of the leading causes of paediatric dysentery, impacting over 165 million cases and 60,000 deaths annually[10]. *Campylobacter* and non-typhoidal *Salmonella* are also the common causative agents of bacterial diarrhoea[11]. Entero-parasitic infections have emerged as significant public health challenges in Sub-Saharan African countries, which can be attributed to overcrowding and inadequate sanitation[12]. Entero-parasitic infections are the leading causes of diarrhoea, morbidity, and a variety of physiological abnormalities in paediatrics[12,13]. Reports suggest that approximately 32% of paediatric patients in Ethiopia are infected with at least any one protozoan species[14].

The prevalence and causes of paediatric diarrhoea vary depending on geography and seasons. Factors associated with diarrhoea are complex and multifactorial. The demography characteristics, clinical and environmental factors can also influence the mortality and morbidity associated with paediatric diarrhoea[6].

In Ethiopia, diarrhoea is the second leading cause of death among paediatrics, following pneumonia[15]. Despite different interventions and schemes to control the menace, diarrhoea-associated mortality in the country is still on the rise, with an Integrated Global Action Plan for the Prevention and Control of Diarrhoea intervention, corresponding to a score of 48% in 2022[16].

As per the WHO guidelines, diarrhoea must be managed with fluid replacement therapy, whereas dysentery can be treated with antibiotics. To minimise the intensity and duration of symptoms, bacterial diarrhoea requires effective empirical treatment regimens. Due to the lack of specific diagnostic facilities, clinicians often prescribe broad-spectrum antibiotics to treat diarrhoea. This can result in adverse effects (toxicity) and even contribute to the emergence and spread of drug-resistant bacteria, particularly in developing countries[17]. Recently, there has been a stark rise in the prevalence of diarrhoea associated with *Salmonella*, *Shigella*, and *Campylobacter* in Ethiopia[11,15,17].

Diarrhoea is a common referral for admissions in healthcare facilities of Arba Minch; apart from rehydration and zinc supplementation, most diarrheal cases in the study area are only empirically treated based on clinical suspicion of bacterial etiology, often resulting in treatment failures[18]. Also, the overuse of antibiotics in paediatrics is a matter of grave concern[18]. A previous study revealed the presence of MDR *Salmonella* and *Shigella* species in the locality[15]. Recently, outbreaks due to *Vibrio* O139 serogroups have also been reported. Updation of information in regard to the causative agents of acute diarrhoea and their susceptibility patterns at regular intervals is essential. This will support the evidence-based clinical decision-making process and also the optimisation of therapeutic regimens. This study was designed to illustrate the prevalence of both entero-bacteria and entero-parasites and the associated factors existing among diarrheic paediatrics attending four selected government health institutions in Arba Minch.

Materials and methods

Study design, area, period, population, and eligibility criteria

The institution-based cross-sectional study was conducted from October 21 to December 30, 2022. The paediatric patients in the study area face significant risks of contracting various communicable diseases due to inadequate supply of water, poor sanitation, and hygiene practices (WASH). The data from health institutions in Arba Minch indicate that acute diarrhoea represents an important public health challenge in the paediatric population. This issue is primarily attributable to factors such as malnutrition, insufficient access to safe potable water, and inadequate sanitation and hygiene practices, and it is recognised as one of the top five contributors to morbidity among children in the region.

Approximately eight to ten paediatric patients presenting with diarrhoea per day seek care at the emergency and outpatient departments of the Government Health Institutions in the study area. The paediatric aged 1–14 years, clinically diagnosed with acute diarrhoea (defined as the presence of three or more episodes of loose stools in the previous 24 h, as per WHO guidelines), who visited the outpatient departments of any one of the four selected health institutions (Arba Minch General Hospital, Dil Fana Primary Hospital, Secha Health Center, and Woze Health Center) represent the source population. These institutions were located in the Gamo Zone of the Southern Nations, Nationalities, and Peoples' Region. All paediatrics (both sexes) of age group 1–14 years, who attended the outpatient wards for treatment during the study period and were clinically diagnosed by a paediatrician, were included. Participants who were unable to give stool samples, who took adjunct medications (probiotics, antidiarrheal, antibiotics, and antiparasitic drugs) for acute diarrhoea, two weeks prior to the commencement of the study, and patients with incomplete medical records were excluded.

Sample size and sampling technique

The Epi-Info version 7.2 software was used to determine the sample size by adopting the assumptions corresponding to a single population proportion formula, obtained from the predicted prevalence of 32% chosen from a previous work conducted in Addis Ababa among paediatrics ≤ 14 years[14]. A confidence interval of 95% (z = 1.96) and 5% of marginal error (d = 0.05) was considered, as given below.

$$n = (Z\alpha/2)^2 * P(1-P)/d^2$$

$$n = 3.84 * 0.32(1-0.32)/(0.05)^2$$

$$n = 334$$

where, n = the required sample size, Zα/2 = standard normal variant at 5% ($P < 0.05$) error or 95% confidence interval, 1.96, P = proportion of diarrheic patients from a previous study, 1 – P = proportion of patients without infections (q), d = absolute error margin, 0.05.

Finally, by computing a 10% non-response rate, the sample size became 367.

The predicted sample size ($n = 367$) was then allocated proportionately to each study setting; the representative sample size was arrived at through a systematic sampling technique, and the sampling interval was calculated by dividing the total number of study subjects by the pre-determined sample size, as outlined in a recent annual report. The K^{th} value was derived from the number of patients who attended the study settings during the study period, and the first participant was selected by a lottery method, and subsequent subjects were recruited systematically at every K^{th} value, maintaining a systematic sampling framework.

Data collection

Before the collection of data and samples, written informed consents were obtained from the parents of each participant after a clear briefing on the purpose of the study. The interviews were conducted with the help of well-trained health professionals. A pre-tested structured questionnaire was arranged to collect the demographic, socioeconomic, behavioural, and clinical data through face-to-face interviews with parents/caretakers.

Sample collection

The parents/caretakers of paediatrics were instructed to aseptically collect the samples (5 gm of loose stool/10 ml of watery stool) by using the supplied sterile, disinfectant-free, leak-proof stool cups labelled with unique identification numbers. The collected samples were examined for the presence of blood, pus, or mucous in the stool and were then inoculated onto Selenite F broth (Oxoid, Basingstoke, UK) for bacteriological isolation and incubated at 37 °C for 24 h. The broth was sub-cultured onto MacConkey agar and xylose lysine deoxycholate (XLD) agar (Oxoid, Basingstoke, UK), incubated under aerobic conditions at 37 °C for 24 h. The growth of *Salmonella* and *Shigella* species was identified morphologically. The isolated colonies were subjected to a series of biochemical tests (catalase, oxidase, indole, hydrogen sulfide, citrate, urease, and carbohydrate fermentation tests) to facilitate the identification[19]. The corresponding American Type Culture Collection strains were taken as reference. To isolate *Campylobacter* species, *Campylobacter* agar base supplemented with 10% sterile defibrinated sheep blood and rehydrated contents of *Campylobacter* Supplement-I (Blaser-Wang) (FD006) was used. Agar plates were then incubated under microaerophilic conditions, specifically at 5–10% oxygen and 10% carbon dioxide, at a temperature of 42 °C for 24 to 48 h. Following incubation, Gram staining, motility tests, and biochemical tests (catalase and oxidase tests, and susceptibility to cephalothin and nalidixic acid discs) were performed to identify the *Campylobacter* species[19]. A reference strain of *Campylobacter jejuni* (ATCC 700819) served as the quality control standard.

Samples were inspected for the presence of cysts, oocysts, eggs, trophozoites, and larvae of enteroparasites microscopically with physiological saline, and also by the formol–ether concentration technique[20].

Antibiotic susceptibility testing

The antibiotic susceptibility profile was determined using the Kirby–Bauer disc diffusion technique, following the guidelines set by CLSI[21]. Inocula were prepared (*Salmonella* and *Shigella*) in normal saline, and the density of suspensions were fixed by comparison with an opacity standard, the McFarland 0.5 barium sulphate solution. The respective test organisms were uniformly swabbed over Mueller–Hinton agar (Hi-Media, India), and antibiotic discs were aseptically placed and incubated at 37 °C for 16–18 h. In the case of *Campylobacter* sp., Mueller–Hinton agar supplemented with 5% sheep blood was utilised[22]. Antibiotic discs (Hi-Media, India) employed include ampicillin (10 µg), cephalothin (30 µg), ceftriaxone (30 µg), cefepime (30 µg), tetracycline (30 µg), azithromycin (15 µg), chloramphenicol (30 µg), trimethoprim-sulfamethoxazole (1.25/23.75 µg), nitrofurantoin (300 µg), ciprofloxacin (5 µg), norfloxacin (10 µg), nalidixic acid (30 µg) and clindamycin (30 µg). The diameters of the zone of inhibition around the discs were measured, and the results were classified as susceptible, intermediate, or resistant[22]. A reference strain of *E. coli* (ATCC 25922) served as the quality control.

Data quality control

The quality and completeness of the questionnaire were checked, and 5% of the respondents were pre-tested at Chencha General Hospital; standard operating procedures were followed during all aspects of the work, including sample collection, handling, and examination. A senior laboratory technician and qualified nurses were hired for sample and data collection, respectively, and were given brief and focused training on the purpose and goal of the study, inclusive of data quality, collection procedures, and confidentiality. The sterility of culture media was checked by incubating 5% of them at 37 °C for 24 h, after which the presence of bacterial growth was tested. Standard strains of *Escherichia coli* (ATCC 25922) and *Klebsiella pneumoniae* (ATCC 700603) were obtained from the Ethiopian Public Health Institute.

Statistical analysis

The collected data were coded, cleaned, and entered using Epi-Data version 7.2 and then exported to SPSS software for further analysis. The IBM SPSS Statistics for Windows, version 25 (IBM Corp., Armonk, N.Y., USA) was applied for data analysis, and also for obtaining the descriptive statistics, including frequency, mean, and standard deviations. The dependent variable in the analysis is the prevalence of enteric pathogens, which is described in terms of proportion and 95% confidence interval (CI). In order to assess the associated factors, a bivariable logistic regression analysis was done, and to control the probable confounding effect, only variables with $P \leq 0.25$ from the former analysis were included in the final model, i.e., the multivariable logistic regression analysis. The Hosmer-Lemeshow goodness-of-fit test was employed to assess the fitness of the model. The strength of associations was determined using adjusted odds ratio (AOR) and 95% confidence interval (CI), and statistical significance was assigned only when P values ≤ 0.05.

Ethical considerations
The research protocol was approved by the Institutional Review Board, College of Medicine and Health Science, Arba Minch University (Ref. IRB/1319/2022). This study followed the tenets of the Declaration of Helsinki and its later amendments. After a thorough briefing of all the study-related procedures and associated risk factors, informed written consents were taken from the parents/legal guardians through the survey tool before sample collection. Finally, those who tested positive for enteric pathogens were informed immediately and sent to their respective physicians for appropriate treatment.

Results
Sociodemographic and economic data
Out of the 367 participants enrolled in this study, 34.9% ($n = 128$), 30% ($n = 110$), 18.8% ($n = 69$), and 16.3% ($n = 60$) were from Arba Minch General Hospital, Dil Fana Primary Hospital, Secha Health Center, and Woze Health Center, respectively. The mean age was 6.7 ± 3.7 years, and 42% of them ($n = 155$) were in the age group 5–9 years. The ratio of male to female was 1.1:1, 51.2% ($n = 188$) were from rural areas, and 26.4% ($n = 97$) of mothers were illiterate. Details of the sociodemographic data of participants are shown in Table 1.

Clinical data, behavioural, and hygienic characteristics
More than 50% (53.4%, $n = 196$) of the study participants reported within 1–2 days of the onset of diarrhoea; 54% ($n = 198$) and 46% ($n = 169$) had watery and bloody diarrhoea, respectively; 47.1% ($n = 173$) of the family members had a history of diarrhoea, and 55.3% ($n = 203$) had direct contacts with domestic animals (Table 2).

Prevalence of enteric pathogens
It is to be noted that 39.8% (CI 95% 34.9–45.2) of stool samples tested positive for enteric pathogens, comprising 37.6% (CI 95% 32.7–42.8) entero-parasites and 2.17% (CI 95% 0.8–3.8) enteric bacteria (Table 3). A significant proportion corresponds to *Giardia lamblia* (17.98%, $n = 66$), followed by *Entamoeba histolytica/dispar* (14.44%, $n = 42$). Apart from these intestinal protozoans, *Ascaris lumbricoides* (1.90%, $n = 7$), *Hymenolepis nana* (1.09%, $n = 4$), and *Trichuris trichiura* (0.27%, $n = 1$) were the geo-helminthic infections detected. Enteric bacterial pathogens identified in this study were *Shigella dysenteriae* (1.1%, $n = 4$), *Campylobacter jejuni*, and Salmonella Typhimurium (each accounting for 0.55%, $n = 2$).

Antibiotic susceptibility testing
Invariably, all the tested bacterial isolates were 100% susceptible to ciprofloxacin and chloramphenicol, but were fully resistant to ampicillin and showed variations in their resistance profiles against tetracycline and trimethoprim-sulfamethoxazole. Interestingly, the isolates of *C. jejuni* were 100% susceptible to ceftriaxone, ciprofloxacin, norfloxacin, chloramphenicol, nalidixic acid, and clindamycin. Only 50% of the isolates showed susceptibility to azithromycin, trimethoprim-sulfamethoxazole, and tetracycline; however were 100% resistant to ampicillin and cephalothin.

The isolates of *S. dysenteriae* were susceptible to ceftriaxone, nitrofurantoin, ciprofloxacin, cefepime, chloramphenicol, and azithromycin to an extent of 75–100%. On the other hand, they showed resistance to ampicillin and tetracycline (100%), trimethoprim-sulfamethoxazole (75%), and nalidixic acid (50%). The isolates of Salmonella Typhimurium were susceptible to nitrofurantoin, ciprofloxacin, trimethoprim-sulfamethoxazole (100% each), norfloxacin, chloramphenicol and tetracycline (50% each) and were resistant to ampicillin (100%), chloramphenicol, norfloxacin, and tetracycline (50% each) (Table S1).

Factors associated with enteric infections
Bivariable analysis revealed that the location of residence, occupation of parents/caretakers, family size, source of potable water, availability of latrine, habit of hand washing before meals, stored food, paternal educational level, and bloody diarrhoea were statistically associated ($P \leq 0.25$). As per the multivariable analysis, the educational level of parents (AOR = 5.46, 95% CI (1.79–16.66) and presence of bloody diarrhoea (AOR = 3.01, 95% CI (1.65–5.48) were associated with enteric infections (Table 4).

Discussion
Diarrheal diseases among paediatrics have become a serious health concern in Ethiopia, and the exact incidence of acute diarrhoea remains unclear. Moreover, there exists only limited capability in most healthcare settings to investigate the etiology of paediatric diarrhoea, primarily due to the lack of apt diagnostic facilities and their prohibitive cost. The paediatric population in our study area experienced higher rates of diarrhoeic infections, 39.8% (CI 95% 34.9–45.2). These conditions existing in our study settings indicate the importance of addressing the issue urgently, and it stands severe compared to the results of earlier studies conducted in Kenya (40.5%)[23] and the eastern and central coasts of Ghana (36%)[24].

The prevalence found in the present study hints at a worse situation than that reported from Wegera, another part of the country (31%), Burundi (32.6%), Uganda (29.1%), Yemen (29.07%), Indonesia (18.21%), Philippines

Variables	Categories	Frequency (n)	Percent (%)
Health institutions	Arba Minch General Hospital	128	34.9
	Dil Fana Primary Hospital	110	30.0
	Secha Health Center	69	18.8
	Woze Health Center	60	16.3
Age (years)	1–4	121	33.0
	5–9	155	42.2
	10–14	91	24.8
Sex	Male	193	52.6
	Female	174	47.4
Residence	Urban	179	48.8
	Rural	188	51.2
Marital status of parents/guardians	Married	100	27.2
	Unmarried	140	38.1
	Divorced	127	34.6
Maternal educational level	Illiterate	97	26.4
	Read and write	71	19.3
	Elementary	78	21.3
	High school	76	20.7
	College and above	45	12.3
Paternal educational level	Illiterate	91	24.8
	Read and write	71	19.3
	Elementary	76	20.7
	High school	74	20.2
	College and above	55	15.0
Occupational status of parents/guardians	Homemaker	72	19.6
	Merchant	79	21.5
	Government employee	76	20.7
	Student	63	17.2
	Labors	77	21.0
Family size	< 5	204	55.6
	≥ 5	163	44.4
Monthly income of the family (Birr)	< 500	95	25.9
	500–1500	101	27.5
	1501–2500	74	20.2
	>2500	97	26.4

Table 1. Sociodemographic and economic characteristics.

(8.39%) and Malaysia (4.4%)[25–30], however, is much better compared to the status of other African countries, viz., Angola (91%), Ghana (93%), and Gabon (50%)[31–33]. These fluctuations in prevalence could be attributed to the non-uniformity in sociodemographic and economic characteristics of study participants, sample size analysed, environmental sanitation practices, geography, and seasonality. Other causes of diarrhoea involve viruses, certain bacteria, or even some type of non-infectious etiology.

Entero-parasitic infections were found to be the most prevalent cause of diarrhoea in this study. We have identified five different species of enteroparasites, and the principal parasitic protozoans found were *G. lamblia* and *E. histolytica/dispar*. The isolation rate of the former observed (17.9%, $n = 66$) resembles the results of a study carried out in Tigray, Ethiopia[34], however, was higher than that reported from Bahir Dar[35], Addis Ababa[36], Birbir[37], and also Egypt[38], which correspond to a broader range, 5.4–12.5%. The isolation rate of *E. histolytica/dispar* was more (14.4%, $n = 42$) than that reported from all the above-mentioned parts of the country, 1.4–10.8%[34–37]. In the present study, *A. lumbricoides* ($n = 7$) was the third most commonly isolated parasite and is at par with the results of earlier studies conducted in Bahir Dar[35] and Addis Ababa[36]. Various factors may also affect the results of studies, such as differences in laboratory diagnostic techniques employed, sample size involved, duration of study, sociodemographic, clinical, and behavioural characteristics of study participants.

Acute diarrhoea in general is considered as the second most common bacterial infection in paediatric patients; however, its prevalence observed in our study is significantly lower ($n = 8$, 2.1%). Only three species of enterobacteria were detected; *S. dysenteriae* was the predominant isolate ($n = 4$), and it fell within the isolation rates reported in a couple of previous studies done in Debre Markos (3.6%) and Hawassa (4.2%)[9,39]. But, the condition is less severe than those found in previous studies conducted in other regions of Ethiopia [Adama (23.8%) and Bahir Dar (30%)] and also Angola (18%)[8,31,40]. There were no cases of bacterial-parasitic co-

Variables	Categories	Frequency (n)	Percent (%)
Onset of diarrhoea (days)	1–2	196	53.4
	3–4	171	46.6
Episode of diarrhoea	Yes	169	46.0
	No	198	54.0
Type of diarrhoea	Watery	198	54.0
	Bloody	169	46.0
Family members with previous diarrhoea status	Yes	173	47.1
	No	194	52.9
Drinking water source	Pipe water	130	35.4
	Groundwater	117	31.9
	Spring water	120	32.7
Latrine service	Private	195	53.1
	Public	172	46.9
Cooked food storage for later use	In an open container	184	50.1
	In a closed container	183	49.9
Hand washing habit after toileting	Sometimes with water	142	38.7
	Always with water	120	32.7
	Always with water and soap	105	28.6
Habit of hand washing before the meal	Always with water	127	34.6
	Sometimes with water	117	31.9
	Always with water and soap	123	33.5
Dry and liquid waste disposal	Not available	155	42.2
	Dry and liquid wastes are disposed of together	111	30.2
	Dry and liquid wastes are disposed of separately	101	27.5
Kind of domestic animals	Cattle	91	24.8
	Sheeps/goats	101	27.5
	Dogs	81	22.1
	Chickens	94	25.6
Direct contact with domestic animals	Yes	203	55.3
	No	164	44.7

Table 2. Clinical data, behavioural, and hygienic factors connected to paediatric diarrhoea.

	Paediatric patients' age (years)			Total
Entero-pathogens	**1–4 (n = 121)**	**5–9 (n = 155)**	**10–14 (n = 91)**	**≤ 14 (n = 367)**
Entero-parasite species n (%)				
G. lamblia	22 (18.18)	25 (16.13)	19 (20.88)	66 (17.98)
E. histolytica	12 (9.92)	19 (12.26)	11 (12.09)	42 (14.44)
A. lumbricoides	–	4 (2.58)	3 (3.23)	7 (1.90)
H. nana	–	2 (1.29)	2 (2.12)	4 (1.09)
T. trichiura	1 (0.83)	–	–	1 (0.27)
Total	35 (28.93)	50 (32.26)	35 (38.32)	120 (32.7)
Enteric bacterial isolates				
S. typhimurium	1 (0.83)	1 (0.64)	–	2 (0.54)
S. dysenteriae	2 (1.65)	1 (0.64)	1 (1.09)	4 (1.1)
C. jejuni/coli	2 (1.65)	–	–	2 (0.54)
Total	5 (4.13)	2 (1.28)	1 (1.09)	8 (2.17)
Double entero-parasite infections				
G. lamblia and *E. histolytica*	6 (4.9)	4 (2.58)	1 (1.09)	11 (2.99)
A. lumbricoides and *E. histolytica*	–	2 ((1.29)	–	2 (0.54)
A. lumbricoides and *G. lamblia*	–	3 (1.93)	1 (1.09)	4 (1.1)
G. lamblia and *H. nana*	1 (0.83)	–	–	1 (0.27)
Total	7 (5.73)	9 (5.8)	2 (2.18)	18 (4.90)

Table 3. Prevalence of enteric infections connected to paediatric diarrhoea.

Variables	Enteric pathogen		COR 95% CI	*P* value	AOR 95% CI	*P* value
	Positive *n* (%)	Negative *n* (%)				
Age (years)						
1–4	46 (31.3)	75 (34.1)	0.89 (0.51–1.56)	0.696		
5–9	64 (43.5)	91 (41.1)	1.02 (0.60–1.73)			
10–14	37 (25.2)	54 (24.5)	1			
Sex						
Male	81 (55.1)	112 (50.9)	1.18 (0.77–1.79)	0.431		
Female	66 (44.9)	108 (49.1)	1			
Residence						
Urban	61 (41.5)	118 (53.6)	1			
Rural	86 (58.5)	102 (46.4)	1.63 (1.07–2.48)	0.023	1.13 (0.65–1.96)	0.654
Marital status of parents/guardians						
Divorced	53 (36.1)	74 (33.6)	1.12 (0.65–1.91)	0.677		
Unmarried	55 (37.4)	85 (38.6)	1.01 (0.59–1.71)	0.964		
Married	39 (26.5)	61 (27.7)	1			
Paternal educational level						
Illiterate	54 (36.7)	37 (16.8)	6.56 (2.94–14.65)	0.000	5.46 (1.79–16.66)	0.003
Read and write	33 (22.4)	38 (17.3)	3.90 (1.70–8.95)	0.001	2.84 (0.87–9.27)	0.083
Elementary	25 (17.0)	51 (23.2)	2.20 (0.95–5.08)	0.064	1.68 (0.52–5.47)	0.385
High school	25 (17.0)	49 (22.3)	2.29 (0.99–5.30)	0.052	1.46 (0.43–4.91)	0.540
College and above	10 (6.8)	45 (20.5)	1			
Occupational status of parents/guardians						
Homemaker	34 (23.1)	38 (17.3)	2.68 (1.33–5.38)	0.005	1.74 (0.51–5.87)	0.369
Merchant	34 (23.1)	45 (20.5)	2.26 (1.14–4.49)	0.019	1.24 (0.43–3.56)	0.681
Labor work	31 (21.1)	46 (20.9)	2.02 (1.01–4.03)	0.046	0.62 (0.19–2)	0.432
Student	29 (19.7)	34 (15.5)	2.55 (1.24–5.24)	0.010	1.04 (0.34–3.19)	0.936
Government Employee	19 (12.9)	57 (25.9)	1			
Family size						
< 5	81 (55.1)	138 (62.7)	1			
≥ 5	66 (44.9)	82 (37.3)	1.37 (1.35–3.15)	0.001	1.48 (0.82–2.67)	0.187
Maternal educational level						
Illiterate	46 (31.3)	51 (23.2)	1.48 (0.72–3.06)	0.283		
Read and write	32 (21.8)	39 (17.7)	1.351 (0.63–2.89)	0.439		
Elementary	29 (19.7)	49 (22.3)	0.97 (0.45–2.07)	0.947		
High school	23 (15.6)	53 (24.1)	0.71 (0.32–1.55)	0.397		
College and above	17 (11.6)	28 (12.7)	1			
Family monthly income in Ethiopian Birr						
< 500	56 (38.1)	39 (17.7)	4.89 (2.61–9.16)	0.000	2.96 (1.10–7.96)	0.031
500–1500	44 (29.9)	57 (25.9)	2.63 (1.42–4.87)	0.002	1.99 (0.75–5.25)	0.161
1501–2500	25 (17.0)	49 (22.3)	1.73 (0.88–3.42)	0.109	1.34 (0.53–3.41)	0.527
> 2500	22 (15.0)	75 (34.1)	1			
Onset of diarrhoea						
3–4 days	83 (56.5)	113 (51.4)	1.22 (0.80–1.86)	0.338		
1–2 days	64 (43.5)	107 (48.6)	1			
Episode of diarrhoea						
Yes	73 (49.7)	96 (43.6)	1.27 (0.83–1.93)	0.257		
No	74 (50.3)	124 (56.4)	1			
Type of diarrhoea						
Bloody	87 (59.2)	82 (37.3)	2.44 (1.59–3.74)	0.000	3.01 (1.65–5.48)	0.000
Watery	60 (40.8)	138 (62.7)	1			
Source of drinking water						
Pipe water	41 (27.9)	89 (40.5)	1			
Groundwater	49 (33.3)	68 (30.9)	1.56 (0.92–2.63)	0.092	1.56 (0.81–3.02)	0.183
Spring water	57 (38.8)	63 (28.6)	1.96 (1.17–3.28)	0.010	1.76 (0.87–3.56)	0.1133
Family members with a history of diarrhoea						
Continued						

Variables	Enteric pathogen		COR 95% CI	*P* value	AOR 95% CI	*P* value
	Positive *n* (%)	Negative *n* (%)				
Yes	74 (50.3)	99 (45.0)	1.23 (0.81–1.88)	0.316		
No	73 (49.7)	121 (55.0)	1			
Latrine service						
Private	64 (43.5)	131 (59.5)	1			
Public	83 (56.5)	89 (40.5)	1.90 (1.25–2.91)	0.003	1.69 (0.94–3.06)	0.80
Fingernail status						
Trimmed	35 (23.8)	119 (54.1)	1			
Not trimmed	112 (76.2)	101 (45.9)	3.77 (2.37–5.99)	0.000	3.07 (1.70–5.54)	0.000
Cooked food for later use						
In an open container	89 (60.5)	95 (43.2)	2.01 (1.32–3.08)	0.001	1.50 (0.83–2.71)	0.171
In a closed container	58 (39.5)	125 (56.8)	1			
Child's habit of hand washing after toilet						
Always with water	51 (34.7)	69 (31.4)	1.25 (0.73–2.13)	0.413		
Sometimes with water	57 (38.8)	85 (38.6)	1.13 (0.67–1.9)	0.633		
Always with water and soap	39 (26.5)	66 (30.0)	1			
Dry and liquid waste disposal						
Not available	58 (39.5)	97 (44.1)	0.87 (0.52–1.46	0.610		
Solid and liquid wastes disposed off together	48 (32.7)	63 (28.6)	1.11 (0.64–1.92)	0.696		
Solid and liquid wastes are disposed off separately	41 (27.9)	60 (27.3)	1			
Direct contact with domestic animals						
Yes	84 (57.1)	119 (54.1)	1.13 (0.742–1.72)	0.565		
No	63 (42.9)	101 (45.9)	1			
Kind of domestic animals						
Cattles	34 (23.1)	57 (25.9)	0.87 (0.48–1.58)	0.669		
Sheep/goat	42 (28.6)	59 (26.8)	1.04 (0.59–1.85)	0.869		
Dogs	33 (22.4)	48 (21.8)	1.01 (0.55–1.85)	0.966		
Chickens	38 (25.9)	56 (25.5)	1			
Habit of hand washing before the meal						
Always with water	57 (58.8)	70 (31.8)	1.96 (1.16–3.31)	0.011	1.51 (0.75–3.03)	0.242
Sometimes with water	54 (36.7)	63 (28.6)	2.07 (1.21–3.52)	0.007	1.44 (0.73–2.84)	0.285
Always with water and soap	36 (24.5)	87 (39.5)	1			

Table 4. Bivariable and multivariable logistic regression analyses of different factors connected to paediatric diarrhoea. Statistically significant at $P \leq 0.25$ in bivariable analysis; statistically significant at $P < 0.05$; AOR: Adjusted odd ratio; COR: Crude odds ratio, 1: reference group, CI: Confidence interval.

infections as per our study; further comprehensive studies are needed to explore the prevalence and impact of co-infections in regard to paediatric diarrhoea.

It is to be specified that Salmonella Typhimurium and *C. jejuni* were found only in two cases each. The rate of isolation of the former detected in our study resembles the results of some of the previous reports from Ethiopia (Ambo and Hosanna)[41,42] as well as Cape Verde (0.95%)[43] and Jordan[44], however, is lower compared to that reported in another study from Debre Birhan[45] and also Zambia (25.5%)[46]. The isolation rate of *C. jejuni* was merely 0.54%, which remains much lower than that described in other studies conducted in Jimma (6.8%)[11], Hawassa (15%)[47], and also the neighbouring country, Kenya (12.9%)[48]. Poor hygiene standards and permanently living in unsanitary conditions can increase the chance of contracting diarrhoea. These findings suggest that the prevalence of enteropathogens may vary considerably across different regions, highlighting the need for conducting periodic region-specific studies to have an exact assessment of prevalence.

The use of fluoroquinolones can increase the risk of peripheral neuropathy in paediatric population[49]; however, there exists a silver line that both *Salmonella* and *Shigella* isolates were fully susceptible to ciprofloxacin, suggesting that this antibiotic is still effective in all the four study settings, which is also in accordance with earlier reports from Ethiopia itself (Arba Minch, Hawassa, and Gondar), Kenya and Mozambique[9,15,48,50,51]. In contrast, a study done among Nepalese children reported high prevalence of ciprofloxacin-resistant *Campylobacter*, *S. dysenteriae* and *S. flexneri*[52]. Isolates of *Salmonella* and *Shigella* were fully resistant to ampicillin and were, by and large, similar to those reported from Iran and the US[53,54]. The isolates of *Campylobacter* exhibited resistance to some of the commonly prescribed first-line antibiotics in the study settings, like trimethoprim/sulfamethoxazole[48]. A cross-institutional pilot study on diarrheal bacterial pathogens collected from clinical settings in the USA, Cambodia, Egypt, Peru, and Kenya has reported the emergence of drug-resistant isolates of *Campylobacter* spp., *Escherichia coli*, *Salmonella*, and *Shigella* spp[55].

Based on the results of antimicrobial susceptibility test obtained from the current study, clinicians may revise the local antibiotic policy, considering the hemodynamic status of paediatric patients.

Assessing the risk factors involved in diarrhoea is an important step in reducing its prevalence; properly identifying the diarrhoea type is an essential step forward in determining the most appropriate regimen. Paediatric patients afflicted with bloody diarrhoea were found to be three times more likely to harbour enteric pathogens. The results of this study are in line with the findings of a pair of earlier research carried out in Wegera and Dessie, Ethiopia[25,56]. Bloody diarrhoea is a common manifestation of enteric pathogens, causing tissue destruction, cellular infiltration, and colonisation within the colon and rectum cell linings[57]. A vast majority of positive cases are observed among the age group of 5–9 years, and this may be due to their outdoor recreational activities, but this was not statistically significant. Poor quality of water supply, inadequate sanitation, and hygiene (WASH) conditions account for an estimated 88% of diarrheal diseases, and as a consequence, in Ethiopia, more than 250,000 children die each year from related illnesses. This corresponds to 60% of the pathogenic infections causing diarrhoea and other health issues[58]. The educational levels of parents are directly related to their understanding of child nutrition, hygiene, and sanitation practices, as well as awareness on transmission, control, and prevention of enteropathogens[59]. Hygiene is shaped-up by personal factors such as practices, beliefs, norms, and the socioeconomic status of parents/caregivers. Paediatric patients belonging to illiterate parents are 5.46 times more likely to be infected by enteropathogens [(AOR; 5.46, 95% CI (1.79–16.66)] compared to those from educated families. This finding underscores the importance of addressing the issue of low literacy rates, which is a potential contributor to the higher prevalence of enteropathogenic infections in paediatrics. The current set of results displays a significant degree of similarity with the findings of earlier works conducted in various regions of the country (Debre Markos and Gondar)[39,50]. Diarrhoeal diseases and enteric infections mainly arise from unsafe potable water, along with inadequate sanitation and hygiene practices. The WHO guidelines indicate that simple, accessible, and affordable WASH interventions can effectively reduce the risks of diarrhoeal diseases. Implementing WASH and health awareness programmes on the prevention of diarrhoea, aiming at the target population, can mitigate child morbidity to a greater extent[60].

Strengths and limitations

The outcome of this study has implications for reducing diarrhoeal diseases in paediatrics in Arba Minch. The etiological profiles which we describe can be used for evidence-based decision-making and also to improve childcare practices by minimising the occurrence of diarrhoea. It can have an impact on policy making and intervention programs, emphasising the importance of promoting parental educational status, which adds to improved child health in the study area. The focus should be on enlightening households about the importance of sanitation practices in reducing diarrhoea and associated problems. Also, it is noteworthy that the study identified and isolated *C. jejuni/coli* among diarrheic paediatrics, for the first time in Arba Minch. This study involved several healthcare settings, covering a wider study population.

The limitations of the present work include a cross-sectional study design with a reduced number of participants/sample size, shorter duration; besides, it is institution-based and hence may not reflect the actual epidemiological patterns of diarrhoea existing among the entire paediatric population in the community. Moreover, *E. histolytica* was also not distinguished from *E. dispar*; *E. coli* O157:H7 was not isolated from the diarrheic stool samples. The aetiology of viral diarrhoea could not be studied due to laboratory constraints. The nutritional status, seasonality, and hand hygiene practices were also not properly assessed. Further studies are to be conducted in the near future, considering all these limitations.

Conclusions

This is the first report on the prevalence of diarrhoea among paediatrics in Arba Minch, which stands at a relatively higher level. This study revealed the presence of a predominant entero-pathogen, *G. lamblia*. Other pathogens, such as *E. histolytica/dispar* and *A. lumbricoides*, were the second and the third most dominant parasites isolated, respectively; however, only a few numbers of diarrheic cases were associated with enteric bacteria such as *S. dysentery* followed by *Campylobacter jejunum/coli* and Salmonella Typhimurium. Invariably, all bacterial isolates were 100% susceptible to ciprofloxacin; however, Salmonella Typhimurium, *S. dysentery*, and *C. jejunum/coli* showed 100% resistance to ampicillin. The presence of bloody diarrhoea and parental educational status were significantly associated. Therefore, special efforts should be taken to persuade illiterate parents to attend health awareness programmes on morbidity due to diarrhoea. Besides, Government organisations and stakeholders should enhance WASH programs in Arba Minch by addressing the associated factors identified in this study.

Data availability

Data will be available from the corresponding author upon reasonable request.

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Declarations

Competing interests
The authors declare no competing interests.

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