BMJ Open

Aetiology and risk factors of bacterial gastroenteritis among febrile outpatients at the Dschang District Hospital, West Region of Cameroon: a cross-sectional study

Karimo Ousenu,[1] Leonard Fonkeng Sama ,[1] Innocent Mbulli Ali ,[1,2] Jude Leinyuy Fonbah,[1] Ongbayokolak Sylvie Nadine,[1] Solange Dabou,[1] Christopher Tume[1,3]

To cite: Ousenu K, Sama LF, Ali IM, *et al*. Aetiology and risk factors of bacterial gastroenteritis among febrile outpatients at the Dschang District Hospital, West Region of Cameroon: a cross-sectional study. *BMJ Open* 2021;**11**:e045965. doi:10.1136/bmjopen-2020-045965

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2020-045965).

LFS and IMA contributed equally.

Received 16 October 2020
Accepted 28 July 2021

For numbered affiliations see end of article.

Correspondence to
Dr Christopher Tume; tumechrist@yahoo.com and Dr Innocent Mbulli Ali, Department of Biochemistry, Faculty of Science, University of Dschang, BP 67, Dschang, West Region, Cameroon; dr.alinn@gmail.com

ABSTRACT

Objectives To investigate the bacterial aetiologies and associated risk factors of gastroenteritis among typhoid suspected cases.

Design Cross-sectional study.

Setting This study was conducted at Dschang District Hospital of the Menoua Division, West Region of Cameroon, between April–November 2019 and June 2020.

Participants Participants aged ≥2 years (mean 34±18.77 years) and of both sex suspected of having typhoid fever were included, while non-suspected typhoid cases were excluded. Self-reported sociodemographic and health information at recruitment was obtained from 556 participants.

Methods Collected stool samples were examined macroscopically and microscopically and subjected to culture. After culture, Gram staining was performed, followed by biochemical testing and characterisation using the Analytical Profile Index (API-20E) test kit.

Interventions' No intervention was done during the period of study.

Outcome measures We identified bacterial causing gastroenteritis, and associated risk factors calculated using binary regression, adjusting for sociodemographic and health variables.

Results Of 556 patients, 74.28% tested positive for gastroenteritis. Among pathogens responsible for gastroenteritis, *Escherichia coli* was found to be the main cause (21.1%), followed by *Salmonella typhi* (10.4%), *Citrobacter diversus* (8.2%), *and Proteus mirabilis* (8.2%), *Proteus vulgaris* (7.3%), whereas *Citrobacter* spp and *Yersinia enterocolitica* were less represented among pathogens causing the disease among patients. A significant difference (p=0.002) was observed between abdominal pain and all the micro-organisms isolated from the patients. Patients having primary level of education were significantly associated (p=0.017; 3.163 (95% CI 1.228 to 8.147)) with the prevalence of gastroenteritis. Consumption of beverages (Wald statistic: 4.823; OR: 2.471; 95% CI (1.102 to 5.539); p=0.028), use of modern toilet (Wald statistic: 4.471; OR: 1.723; 95% CI (1.041 to 2.852); p=0.034) were strongly associated with gastroenteritis and rearing of bird (Wald statistic: 4.880; OR: 0.560; 95% CI (0.335 to 0.937); p=0.027), was found to be protective.

Conclusion Acute bacterial gastroenteritis is a significant cause of morbidity in Dschang, with the prevalence of 74.28%. Many pathogens accounted for gastroenteritis, and *E. coli* (21.1%) could be a major cause, followed by *S. typhi* (10.4%), *C. diversus* (8.2%), *P. mirabilis* (8.2%), *P. vulgaris* (7.3%), whereas *Citrobacter* spp and *Y. enterocolitica* were less represented. Gastroenteritis was highly associated with primary level of education, consumption of beverages, use of modern toilet while rearing of birds was unexpectedly found to be protective against Gastroenteritis. Further characterisation is planned.

Strengths and limitations of this study

- ► Microscopy and culture which has sensitivity and specificity of 100%, was used to determine common bacteria causing gastroenteritis.
- ► Stratified sampling technique permits estimation of population parameters for groups within a population was used for sampling.
- ► The present study covers a cross-section of patients with suspected gastroenteritis, so caution should be taken while generalising the results.

INTRODUCTION

Gastroenteritis constitutes one of the major health burdens of infectious diseases throughout the world.[1] It is one of the most common infectious diseases among humans and a major cause of mortality in low-income and middle-income countries.[2] It is the inflammation of gastrointestinal tract (GIT), exemplified by a combination of abdominal pain, cramping, nausea, vomiting, diarrhoea and dehydration.[3] It may be acute or chronic. As acute gastroenteritis, it is usually

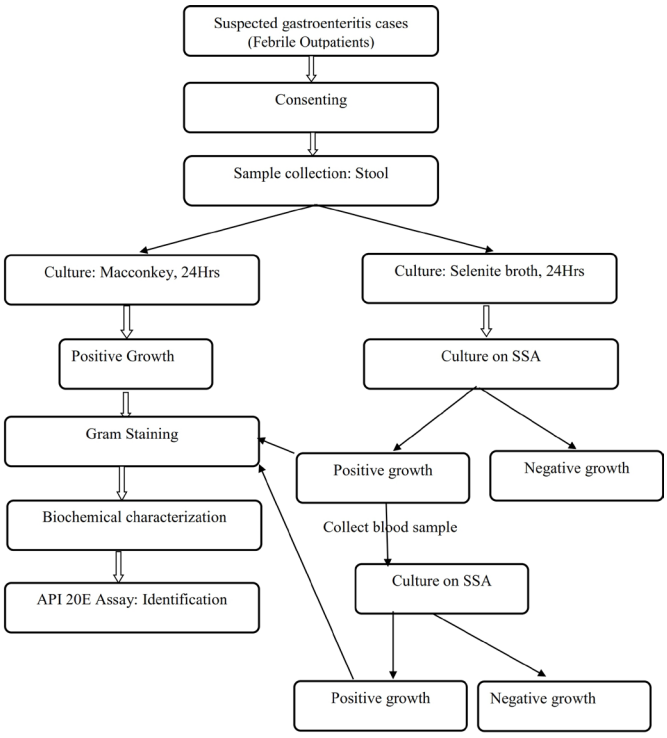

Figure 1 Flow chart for identification ofmicro-organisms. API 20E: Analytical Profile Index for biochemical identification of Enterobiaceae.

less than 14 days, while chronic gastroenteritis is usually between 14 and 30 days.[4] Is a major health hazard that affect individuals of any age but more common in children.[5] Several micro-organisms are responsible for gastroenteritis including viruses but also parasites and bacteria[6] depending on the region. According to studies, almost 87% of the acute gastroenteritis is caused by virus and of which rotavirus is the most common in developed countries while in low-income and middle-income countries, bacteria and helminths may also be the cause.[3] Infectious gastrointestinal illnesses are transmitted through a variety of routes including contaminated food or water borne, the faecal-oral route and person-to-person. Despite the strong association between gastrointestinal illnesses and factors such as poor sanitation, inadequate access to safe drinking water and other risk factors, both resource-rich and less developed countries alike are affected by gastrointestinal illness.[7 8] There are some studies on the prevalence and distribution of pathogens that cause GIT illnesses in children in low-income and middle-income and developed country, but very few characterising GIT illnesses among all age groups.[1] In Cameroon, we observe a high burden of gastroenteritis (hospital base information) but there is no study on the aetiology of gastroenteritis among the population. The aims of the present study were to investigate aetiology and risk factors of gastroenteritis cases presenting among patients visiting the Dschang District Hospital (DDH) for various gastrointestinal complaints.

MATERIAL AND METHODS

Design and location

This cross-sectional study was conducted in DDH, Menoua Division, West Region of Cameroon.

Study area and period

The Menoua Division, West Region of Cameroon has a surface area of 1380 km^2, it is divided into six subdivisions: Dschang, Santchou, Nkong-Ni, Penka Michel, Fokoue and Fongo-Tongo. According to altitude the division has Santchou at an altitude of 600 m, Dschang at 1500 m, its top at the plateau of Djuititsa at an altitude of 2200 m. The Division has an average rainfall of 1717.7 mm and temperature ranges from 13.6°C to 25.35°C. Eighty per cent of inhabitants practice farming as the most important activity and horticultural plants include cabbage, carrot, onion, maize, banana, tomato, plantain, tea and beans. This study was conducted from November 2019 to June 2020.

Sample selection and criteria

Eligible patients were those who had fever (temperature >37.5°C at inclusion) or reported febrile episodes in the past 3 days, presenting one or all of the following symptoms; headache, nausea, abdominal pains, fatigue, vomiting and diarrhoea. Eligible patients who provided consent were enrolled in this study. A questionnaire on demographic and clinical data, and known risk factors for gastrointestinal problems was administered to each participant. All patients that had been on antibiotic medication (or reported self-medication) as well as HIV positive (self-declaration) were excluded. A total of 556 patients were recruited in the study irrespective of age.

Microbiology

Stool samples were examined using standard bacteriology (microscopy or direct observation and cultures).

Sample collection

Approximately 3–4 g of fresh stool was collected by febrile patients who visited laboratory for typhoid test, after brief training on how to collect the sample using a sterile wide-mouthed and transparent container. Accessories were provided to each of the participants. After collection, the stool samples were observed for macroscopic features like presence of mucus, diarrhoea, blood, etc. Microscopic examination of stool was also done after which stool was enriched using selenite broth (1:9) to amplified *Salmonella* spp load if present and incubated for 24 hours. After the 24hours of incubation, broth was then cultured on Salmonella-Shigella Agar (SSA) for isolation of *Salmonella* and *Shigella*. Stool was equally cultured directly on MacConkey agar for differentiation of lactose fermenting and non-lactose fermenting Enterobacteria, the plates were identified into numbers according to sample number and incubated at 37°C for 24 hours in a bacteriological laboratory incubator.

After 24hours, the plates were examined for the presence of characteristic colonies of *Proteus* spp, *Escherichia*

Table 1 Relationships between prevalence of gastroenteritis infection and sociodemographic characteristics

Characteristic	No (n=556)	No (%) infected by gastroenteritis	P value	Characteristic	OR (95% CI)	P value
Gender			0.182	Gender (male/female)	1.184 (0.738 to 1.90)	0.483
Male	182	76.9 (140/182)				
Female	374	73.0 (273/374)				
Age category			0.841		1.013 (0.9911)	0.258
≤10	34	67.6 (23/34)				
11–20	72	73.6 (53/72)				
21–30	224	74.1 (166/224)				
31–40	48	72.9 (35/48)				
41–50	57	70.2 (40/57)				
51–60	52	80.8 (42/52)				
61–70	46	76.1 (35/46)				
71–80	19	78.9 (15/19)				
>80	4	100 (4/4)				
Occupation						
Housewife	120	74.2 (89/120)	0.354	Housewife/nurse	1.432 (0.079 to 25.9)	0.808
Business	55	74.5 (41/55)		Business/nurse	1.712 (0.095 to 30.9)	0.716
Student	237	73.8 (175/237)		Student/nurse	2.725 (0.155 to 47.9)	0.493
Pupils	26	61.5 (15/26)		Pupils/nurse	0.746 (0.033 to 16.832)	0.854
Builder	5	80.0 (4/5)		Builder/nurse	2.556 (0.070 to 93.305)	0.609
Teacher	29	80.7 (26/29)		Teacher/nurse	7.364 (0.349 to 155.572)	0.200
Farmer	33	69.7 (23/33)		Farmer/nurse	1.193 (0.062 to 22.800)	0.907
Hustler	11	90.9 (10/11)		Hustler/nurse	5.842 (0.171 to 200.113)	0.328
Driver	23	69.6 (16/23)		Driver/nurse	1.256 (0.064 to 24.756)	0.881
Tailor	11	81.8 (9/11)		Tailor/nurse	3.038 (0.116 to 79.274)	0.504
Nurses	6	66.7 (4/6)/		/	NA	NA
Level of education			0.192			
Non-educated				/	NA	NA
Primary	75	76.0 (57/75)		Primary/higher	3.163 (1.228 to 8.147)	**0.017**
Secondary	303	75.9 (230/303)		secondary/higher	1.589 (0.980 to 2.578)	0.061
Higher	178	70.8 (126/178)		/	NA	NA
Marital status			0.784			
Married	209	75.6 (158/209)		/	NA	NA
Single	313	73.2 (229/313)		Single/married	0.904 (0.444 to 1.838)	0.780
Widow(er)	34	76.5 (26/34)		Widow(er)/married	0.717 (0.254 to 2.020)	0.529

NA, not available.

coli, *Salmonella* spp, *Citrobacter* spp, *Yersinia* spp, *Enterobacter* spp, *Serratia* spp, *Morganella* spp and *Shigella* spp. For those that had positive stool culture for *Salmonella* spp, blood was collected for further culture. Suspected colonies were restreaked on SSA and MacConkey agar for purification and further identification and confirmation.

Microscopy and biochemical tests

After culture, Gram staining was perform to differentiate Gram positive and Gram negative bacteria. Followed by biochemical tests including using urea test, indole test, citrate test, Mannitol motility test, Kligler Iron Agar. After biochemical test, further characterisation was done using API-20E test kit (BioMerieux, France) as shown in figure 1. The API-20E test is a standardised analytical profile index test is a biochemical panel for Gram negative, Gram positive bacteria and yeast identification among Enterobiaceae; based on detection of enzyme activity.

Patient's information

Demographic information like age, sex, level of education, clinical symptoms for gastroenteritis like fever,

Table 2 Microbiological findings among participants suspected of gastroenteritis infection

Micro-organism	No (n=556)	Frequencies (%)
Shigella		
dysenteriae	13	3.1
sonnei	5	1.2
spp	4	1
Citrobacter		
diversus	34	8.2
freundii	10	2.4
spp	2	0.5
Proteus		
mirabilis	34	8.2
vulgaris	30	7.3
penneri	5	1.2
Salmonella		
arizonae	11	2.7
typhi	43	10.4
paratyphi A	21	5.1
typhimorium	5	1.2
spp	8	1.9
Serratia		
marcescens	8	1.9
odorifera	11	2.7
spp	4	1
Escherichia coli	87	21.1
Klebsiella		
oxytoca	15	3.6
pneumoniae	11	2.7
Edwarsiella		
hoshinae	13	3.1
tarda	5	1.2
Yersinia		
enterocolitica	2	0.5
Providencia		
rettgeri	17	4.1
stuartii	3	0.7
spp	5	1.2
Morganella		
morganii	5	1.2
Enterobacter		
gergoviae	2	0.5

diarrhoea, abdominal cramping were recorded in a questionnaire after a written consent was obtained from each participant.

Patient and public involvement

Research question was generated base on general observation of the patients complain. Priority was giving to patients presenting symptoms that were characteristics of bacteria gastroenteritis. Patients who consented were recruited in the study after receiving information on the objectives of the study. Patients were recruited to provide samples but not to conduct the study because the study was conducted by the principal investigator. Patient results were returned to the consulting physician who did the prescription where necessary. Patients were not randomised.

Statistical analysis

Returned questionnaires were coded, and data were entered into Epi Info V.7.1. Descriptive statistics including mean, frequency and SD were determined and checked for distribution of the data to apply appropriate statistics. χ^2 and Fisher's exact test were used for categorical data, and t-test and Analysis of Variance (ANOVA) were used for continuous data.

Binary logistic regression model was used to identify the most important determining factors for acute gastroenteritis. OR was applied to estimate the relationship between risk factors and gastroenteritis. A p<0.005 was considered significant.

RESULTS

A total of 556 participants presenting symptoms of gastroenteritis at the DDH were recruited in this study. The mean age of the study population was 34±18.77 years with minimum age being 2 years and the maximum 84 years. Among the participants, 77.3% (374/556) were female with mean age of 36.19±19.68 years whereas 37.7% (182/556) were male with mean age of 29.48±15.88 years. The study of the relationships between prevalence of gastroenteritis infection and sociodemographic characteristics shows that only patients having primary level of education was significantly associated with the prevalence of gastroenteritis (p=0.017; 3.163 (95% CI 1.228 to 8.147)] (table 1). Among the participants, 74.28% had gastroenteritis with the following pathogens being responsible, with *E.coli* was the main cause (21.1%), follow by *Salmonella typhi* (10.4%), *Citrobacter diversus* (8.2%), *Proteus mirabilis* (8.2%), *Proteus vulgaris* (7.3%), whereas *Citrobacter* spp and *Yersinia enterocolitica* were less represented among pathogens causing the disease among patients (table 2).

Analysis of the frequency of micro-organisms by clinical symptoms showed there were more micro-organisms among those with abdominal pain (p=0.002) than with other symptoms (table 3). Significant difference was also observed between micro-organisms and type of the patients stool (table 4). The univariate analysis of risk factors associated to gastroenteritis infection showed that consumption of beverages was associated to gastroenteritis (Wald statistic: 4.823; OR: 2.471; 95% CI (1.102 to 5.539); p=0.028), use of modern toilet (Wald statistic: 4.471; OR: 1.723; 95% CI (1.041 to 2.852); p=0.034) were found to be associated with bacterial gastroenteritis and rearing of bird (Wald statistic: 4.880; OR: 0.560; 95% CI

Table 3 Relationship between clinical symptoms and micro-organisms found in patients suspected of gastroenteritis

Micro-organism	Fever	Headache	Nausea	Abdominal pains	Fatigue	Vomiting	Diarrhoea
Shigella							
dysenteriae	2.7% (11)	2.7% (8)	1.2% (1)	2.3% (8)	4.1% (10)	7.5% (4)	3.5% (13)
sonnei	1.2% (5)	1.0% (3)	1.2% (1)	1.5% (5)	1.2% (3)	1.9% (1)	1.3% (5)
spp	1.0% (4)	0.7% (2)	1.2% (1)	1.2% (4)	1.2% (3)	0.0% (0)	1.1% (4)
Citobacter							
diversus	8.3%(34)	9.2% (27)	8.6% (7)	9.3% (32)	6.11% (15)	7.5% (4)	8.0% (30)
freundii	2.4% (10)	3.4% (10)	1.2% (1)	2.0% (7)	1.6% (4)	0.0% (0)	1.9% (7)
spp	0.5% (2)	0.7% (2)	1.2% (1)	0.3% (1)	0.8% (2)	0.0% (0)	0.5% (2)
Proteus							
mirabilis	8.1% (33)	6.8% (20)	11.1% (9)	8.1% (28)	8.9% (22)	15.1% (8)	8.0% (30)
vulgaris	7.3% (30)	8.5% (25)	6.2% (5)	8.1% (28)	8.1% (20)	9.4% (5)	7.2% (27)
penneri	1.2% (5)	1.0% (3)	1.2% (1)	0.3% (1)	1.2% (3)	1.9% (1)	0.8% (3)
Salmonella							
arizonae	2.7% (11)	3.1% (9)	2.5% (2)	2.9% (10)	2.8% (7)	1.9% (1)	2.9% (11)
typhi	10.5% (43)	9.5% (28)	12.3% (10)	11.0% (32)	10.2% (25)	11.3% (6)	10.6% (40)
paratyphi A	5.1% (21)	4.4% (13)	4.9% (4)	5.5% (19)	5.3% (13)	3.8% (2)	5.3% (20)
typhimorium	1.2% (5)	1.0% (3)	0.0% (0)	1.2% (4)	1.6% (4)	1.9% (1)	1.3% (5)
spp	2.0% (8)	2.0% (6)	0.0% (0)	2.3% (8)	1.2% (3)	1.9% (1)	1.9% (7)
Serratia							
marcesens	2.0% (8)	2.4% (7)	2.5% (2)	1.7% (6)	2.0% (5)	1.9% (1)	1.9% (7)
odorifera	2.7% (11)	2.4% (7)	4.9% (4)	1.7% (6)	2.8% (7)	3.8% (2)	2.1% (8)
spp	1.0% (4)	0.7% (2)	2.5% (2)	0.3% (1)	0.8% (2)	3.8% (2)	0.8% (3)
Escherichia coli	21.3% (87)	20.1% (59)	16.0% (13)	20.9% (72)	19.1% (47)	3.4% (3)	21.8% (82)
Klebsiella							
oxytoca	3.4%(14)	3.7% (11)	2.5% (2)	3.8% (13)	3.3% (8)	3.8% (2)	3.5% (13)
pneumoniae	2.7% (11)	2.0% (6)	0.0% (0)	2.6% (9)	2.4% (6)	1.9% (1)	2.9% (11)
Edwarsiella							
hoshinae	3.2% (13)	3.4% (10)	6.2% (5)	3.2% (11)	4.1% (10)	1.9% (1)	3.2% (12)
tarda	1.2% (5)	1.7% (5)	1.2% (1)	1.5% (5)	2.0% (5)	0.0% (0)	1.3% (5)
Yersinia							
Enterocolitica	0.5% (2)	0.3% (1)	2.5% (2)	0.6% (2)	0.0% (0)	1.9% (1)	0.5% (2)
Providencia							
rettgeri	4.2% (17)	5.1% (15)	4.9% (4)	4.1% (14)	4.9% (12)	7.5% (4)	4.3% (16)
stuartii	0.7% (3)	0.7% (2)	1.2% (1)	0.6% (2)	1.2% (3)	1.9% (1)	0.8% (3)
spp	1.2% (5)	1.4% (4)	2.5% (2)	1.2% (4)	1.6% (4)	1.9% (1)	1.3% (5)
Morganella							
Morganii	1.2% (5)	1.4% (4)	0.0% (0)	1.2% (4)	1.2% (3)	0.0% (0)	0.8% (3)
Enterobacter geogoviae	0.5% (2)	0.7% (2)	0.0% (0)	0.6% (2)	0.0% (0)	0.0% (0)	0.5% (2)
Edwardsiella tarda+Serratia marcescens	0.49% (1)	0.68% (1)	0.0% (0)	0.62% (1)	0.80% (1)	0.0% (0)	0.53% (1)
Klebsiella pneumoniae+Proteus vulgaris	0.49% (1)	0.0% (0)	0.0% (0)	0.58% (1)	0.81% (1)	0.0% (0)	0.53% (1)
Klebsiella oxytoca+Edwarsiella tarda	0.48% (1)	0.68% (1)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.53% (1)
E. coli+Citobacter diversus	0.49% (1)	0.68% (1)	0.0% (0)	0.58% (1)	0.0% (0)	0.0% (0)	0.54% (1)
Providencia stuartii+E. tarda	0.47% (1)	0.0% (0)	0.69% (1)	0.0% (0)	0.80% (1)	1.9% (1)	0.53% (1)
P value	0.068	0.427	0.253	0.002	0.388	0.259	0.186

Table 4 Association between micro-organism and type of stool of suspected gastroenteritis patients

Micro-organisms	Bloody (%)	Hard (%)	Mucoid (%)	Watery (%)
Citrobacter diversus	0.0 (0)	5.9 (2)	67.6 (23	26.5 (9)
Citrobacter freundii	10.0 (1)	30.0 (3)	60.0 (6)	0.0 (0)
Citrobacter spp	0.0 (0)	0.0 (0)	100(2)	0.0 (0)
Escherichia coli	24.1 (21)	4.6 (4)	42.5 (37)	28.7 (25)
Edwardsiella hoshinae	7.7 (1)	7.7 (1)	38.5 (5)	46.2 (6)
Edwardsiella tarda	0.0 (0)	0.0 (0)	40.0 (2)	60.0 (3)
Enterobacter gergoviae	0.0 (0)	0.0 (0)	100(2)	0.0 (0)
Klebsiella oxytoca	0.0 (0)	13.3 (2)	53.3 (8)	33.3 (5)
Klebsiella pneumoniae	0.0 (0)	0.0 (0)	54.5 (6)	45.5 (5)
Morganella morganii	0.0 (0)	40.0 (2)	40.0 (2)	20.0 (1)
Proteus mirabilis	0.0 (0)	8.8 (3)	79.4 (27)	11.8 (4)
Proteus penneri	20.0 (1)	40(2)	20.0 (1)	20.0 (1)
Providencia rettgeri	5.1 (1)	5.1 (1)	52.9 (9)	35.3 (6)
Providencia spp	0.0 (0)	0.0 (0)	80.0 (4)	20.0 (1)
Providencia stuartii	0.0 (0)	0.0 (0)	66.7 (2)	33.3 (1)
Salmonella arizonae	9.1 (1)	0.0 (0)	27.3 (3)	63.6 (7)
Salmonella paratyphi A	0.0 (0)	4.8 (1)	38.1 (8)	57.1 (12)
Salmonella spp	12.5 (1)	12.5 (1)	25.0 (2)	50.0 (4)
Salmonella typhi	0.0 (0)	7.0 (3)	27.9 (12)	65.1 (28)
Salmonella	0.0 (0)	0.0 (0)	20.0 (1)	80.0 (4)
Serration marcesens	0.0 (0)	12.5 (1)	87.5 (7)	0.0 (0)
Serratia odorifera	0.0 (0)	18.2 (2)	63.6 (7)	18.2 (2)
Serratia spp	0.0 (0)	25.0 (1)	75.0 (3)	0.0 (0)
Shigella dysenteriae	53.8 (7)	0.0 (0)	0.0 (0)	46.2 (0)
Shigella sonnei	80.0 (4)	0.0 (0)	0.0 (0)	20.0 (1)
Shigella spp	25.0 (1)	0.0 (0)	0.0 (0)	75.0 (3)
Yersinia enterocolitica	0.0 (0)	0.0 (0)	50.0 (1)	50.0 (1)
P value	<0.000	<0.000	0.000	0.000

(0.335 to 0.937); p=0.027) was found to be protective (table 5).

DISCUSSION

Up to date, gastroenteritis constitutes an important problem of commonly observed diseases, which ranges from inconvenience to mortality despite the wide use of oral rehydration therapy. The main symptoms of gastroenteritis are abdominal cramps, nausea and vomiting, diarrhoea, loss of appetite, weakness, fever or chills and dehydration which arise mainly due to bacterial, viral and parasitic infections.[9] The study of relationships between prevalence of gastroenteritis and sociodemographic characteristics shows that there is an association between pupils and gastroenteritis p=0.017 (3.163 (95% CI 1.228 to 8.147)) though no significant difference was observed between infected and non-infected patients with primary level of education. This association may be due to poor hygienic practice and insalubrity, similar to result obtained by Mushtaq *et al*.[3] *E. coli* and *Salmonella* spp were highly represented among bacteria responsible for the gastroenteritis. While this high prevalence of *E.coli* could be because it represents the most abundant Enterobacteria in the GIT under normal condition, it could well be that increased virulence observed in *E. coli* gastroenteritis may have occurred in local isolates. No previous study in our setting has identified virulence factors in *E. coli* and thus represents an avenue to explore in the near future. A second reason *E. coli* could become pathogenic relates to host immune depression. Such results were observed in the study conducted in Uruguay but also in Australia where high prevalence of *E. coli* was observed among pathogens causing gastroenteritis.[10 11] The prevalence of *salmonella* species observed in the present study is very high compared with that observed in a similar study conducted in the USA.[12] This high prevalence found in our study could be due lack of potable water in developing countries among which is Cameroon. We observe in our local setting that pipeborne water supply is poorly distributed and often non-operational.

The distribution of clinical symptoms according to micro-organisms showed a significant difference with

Table 5 Analysis of risk factors associated with gastroenteritis

Risk factors		Gastroenteritis Positive	Gastroenteritis Negative	P value	Wald	OR	95% CI	P value
Types of water	Forage water	75.4% (89)	24.6% (29)	0.269	NA	NA	NA	NA
	Mineral water	0.0% (0)	100% (1)		NA	NA	NA	NA
	Stream water	75.3% (213)	24.7% (70)		0.001	0.991	0.602 to 1.632	0.973
	Tap water	71.3% (107)	28.7% (43)		0.562	0.811	0.468 to 1.403	0.454
	Well water	100% (4)	0.0% (0)		NA	NA	NA	NA
Water treatment		74.0% (77)	26.0% (27)	0.520	0.039	0.950	0.570 to 1.583	0.844
Consumption of beverages		86.7% (52)	13.3% (8)	0.012	4.823	2.471*	1.102 to 5.539	0.028
Eating out of home		75.6% (235)	24.4% (76)	0.247	0.297	1.140	0.712 to 1.824	0.586
Eating undercook food		75.6% (15)	24.4% (3)	0.278	0.763	1.787	0.486 to 6580	0.382
Sharing food in the same plate		71.9% (64)	28.1% (25)	0.331	1.385	0.717	0.413 to 1.247	0.239
Eating salad and raw vegetables		74.0% (248)	26.0% (87)	0.474	0.329	0.869	0.537 to 1406	0.566
Washing vegetables and fruits before used		74.3% (305)	25.7% (100)	0.211	0.389	1.154	0.735 to 1.813	0.533
Types of toilets used	Latrine	72.2% (296)	27.8% (114)	0.169	NA	NA	NA	NA
	Modern toilette	80.1% (113)	19.9% (28)		4.471	1.723*	1.041 to 2.852	0.034
	No toilette	80.0% (4)	20.0% (1)		0.228	1.715	0.187 to 15.701	0.633
Rearing of bird		79.0% (109)	21.0% (29)	0.088	4.880	0.560*	0.335 to 0.937	0.027

* mean statistically significant determinant.
N/A, not available.

abdominal pains which was mostly observed in patients infected with *S. typhi, E. coli, C. diversus, P. mirabilis* and *P. vulgaris*. While it is well known that, except for *S. typhi*, these bacteria are opportunistic pathogens responsible for a wide range of infections. The relatively high prevalence among patients with symptoms of gastroenteritis may be related to changes in virulence, or weakened immune response which may offer a window of pathogenicity for the bacteria. Salmonellosis and shigellosis waterborne diseases linked to poor hygiene. These observations corroborate previous studies by by Skyum *et al*.[13]

The distribution of stool type according to micro-organisms showed significant differences which may reflect variations in mechanisms of bacteria gastroenteritis by species of bacteria. These mechanisms include among other mucosal invasion, mucosal invasion, which may either be characterised by absorption of fluids, mal absorption of fluid with the disorder of the intestine.[14]

We found two counterintuitive results. Consumption of beverages and used of modern toilet were significantly risk factors associated with gastroenteritis in the univariate analysis whereas rearing of birds was found to be a protective factor. Several explanations could account for the findings. First, locally manufactured drinks are common and cheap and people mostly consume them though the source of water is used is unknown and hygienic conditions of drinking spots not monitored. Modern toilets could act as vehicles for transmission indirectly through touching of contaminated surfaces and poor personal hygiene. The perception that the use of a modern toilet precludes infection may not always be right in our context. Participants might have wrongly assumed that using a modern toilet precluded transmission of gastrointestinal pathogens. This could result in less observation of personal hygiene measures than would be expected. This can be tested in a future study in which we compare the profile of gut pathogens in participants who use modern vs traditional toilet facilities and a before-and-after study that takes advantage of massive sensitisation following COVID-19 pandemic. The other counterintuitive observation related to protection afforded by rearing of birds. Indeed, we observe that this might actually be a valid observation because of intensive sensitisation campaigns offered by extension workers from a related governmental department in charge of animal husbandry. Second, the perceived risk of exposure to pathogens by participants who rear birds might be different from the rest of the other participants. This perceived risk might lead to increased self-medication or increased hygiene practices among bird rearers compared with other members of the community. However, we did not verify this in the present study. We will closely analyse these findings in the light of a similar study carried out among backyard chicken farmers to lend further support to the hypothesis. None of other factors where independently associated with gastroenteritis.

Our study should be interpreted with some caution. First, the absence of any further characterisation of the *E. coli* limits our ability to attribute a pathogenic role to this micro-organism in the current context. With future funding, studies to subtype key micro-organisms will give us more leverage to determine serotypes associated with symptoms among the studied population. Second, we did not compare patterns of infections with micro-organisms

recovered from a control population. Although our study was not originally conceived this way, we note that such a comparison may shed more light into aetiologies. However, this is one of the first studies to assess aetiologies and risk factors for gastroenteritis in our setting, providing important information with the potential to influence case management practices. With the current shift from isolate based antimicrobial resistance studies to case based studies, our study will provide interesting insights into future antimicrobial resistance studies. Future studies will address hypotheses generated by the current study.

CONCLUSION

In the present study in which we investigated aetiology and risk factors of bacterial gastroenteritis cases presenting at the DDH, we observed that gastroenteritis is a significant cause of morbidity in Dschang, with the prevalence of 74.28%. Many pathogens accounted for gastroenteritis, and *E. coli* (21.1%) could be a major cause, followed by *S. typhi* (10.4%), *C. diversus* (8.2%), *P. mirabilis* (8.2%), *P. vulgaris* (7.3%), whereas *Citrobacter* spp and *Y. enterocolitica* were less represented among pathogens causing the disease among patients. Patients with primary level of education, consumption of beverages, used of modern toilet were found to be associated to gastroenteritis in this study. However, further characterisation studies are needed to cleanly attribute recovered enteropathogens with gastroenteritis among the studied populations.

Author affiliations
[1]Department of Biochemistry, Faculty of Science, University of Dschang, Dschang, West Region, Cameroon
[2]The Biotechnology Centre, BP 8094, University of Yaounde 1, Yaounde, Centre Region, Cameroon
[3]Department of Biochemistry, University of Bamenda, Bambili, Cameroon

Twitter Innocent Mbulli Ali @dr_Ali_Innocent

Acknowledgements We thank all patients who participated. They sacrificed their time and donated stool samples for this study. We also particularly thank doctors, nurses and laboratory technicians who advised patients in this study and provided clinical care for them. We are grateful to the Dschang District Hospital for their administrative support.

Contributors CT and IMA designed the study. KO, LFS and JLF performed sampling and laboratory analysis. SD, OSN, IMA performed statistical analysis. All authors participated in the write-up, revision and approved the final version of the manuscript

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not required.

Ethics approval Ethical clearance was obtained from the National Ethical Committee for Research involving Human Subjects (CNERSH). No 2019/11/56/CE/CNERSH/SP, Yaoundé Cameroon. Research authoriSations were also obtained from all Directors of Districts in the Menoua division and from Directors of the different hospitals where sample and data collection were done. Research authorisation was also granted by the University of Dschang. Data and samples were collected only after informed consent was obtained from each volunteer and guardian.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as online supplemental information. Not applicable

ORCID iDs
Leonard Fonkeng Sama http://orcid.org/0000-0002-2108-5563
Innocent Mbulli Ali http://orcid.org/0000-0002-1112-6376

REFERENCES

1 Fletcher SM, McLaws M-L, Ellis JT. Prevalence of gastrointestinal pathogens in developed and developing countries: systematic review and meta-analysis. *J Public Health Res* 2013;2:e9.
2 Chen Y, Liu BC, Glass K, *et al*. High incidence of hospitalisation due to infectious gastroenteritis in older people associated with poor self-rated health. *BMJ Open* 2015;5:e010161.
3 Mushtaq A, Khan S, Zeb F. Risk factors associated with gastroenteritis in children 2-5 years of age attending Rehman medical Institute Peshawar. *American Journal of Food Science and Health* 2016;2:94–101.
4 Graves NS. Acute gastroenteritis. *Prim Care* 2013;40:727–41.
5 Jones S. A clinical pathway for pediatric gastroenteritis. *Gastroenterol Nurs* 2003;26:7–18.
6 et alSchmidt RH, Goodrich RM, Archer DL. General overview of the causative agents of foodborne illness. 2003. food science and human nutrition department, Florida cooperative extension service, IFAS, University of Florida. Available: http://edis.ifas.ufl.edu/pdffiles/FS/FS09900.pdf
7 Wardlaw T, Salama P, Brocklehurst C, *et al*. Diarrhoea: why children are still dying and what can be done. *Lancet* 2010;375:870–2.
8 UNICEF/WHO. Diarrhoea: why children are still dying and what can be done. UNICEF/WHO joint report on preventing and treating the second leading killer of children, 2009. Available: http://www.unicef.org/health/index_51412.html [Accessed May 2013].
9 Kaushal TR, Vikram AR, Hemant P, *et al*. Prevalence and risk factors associated with gastro-intestinal tract infections in Sikkim. *J Community Med Health Educ* 2012;2:174.
10 Peirano V, Bianco MN, Navarro A, *et al*. Diarrheagenic *Escherichia coli* Associated with Acute Gastroenteritis in Children from Soriano, Uruguay. *Can J Infect Dis Med Microbiol* 2018;2018:1–8.
11 Robins-Browne RM, Bordun A-M, Tauschek M, *et al*. Escherichia coli and community-acquired gastroenteritis, Melbourne, Australia. *Emerg Infect Dis* 2004;10:1797–805.
12 Bresee JS, Marcus R, Venezia RA, *et al*. The etiology of severe acute gastroenteritis among adults visiting emergency departments in the United States. *J Infect Dis* 2012;205:1374–81.
13 Skyum F, Pedersen C, Andersen V, *et al*. Risk factors for contagious gastroenteritis in adult patients with diarrhoea in the emergency department - a prospective observational multicentre study. *BMC Infect Dis* 2019;19:133.
14 Sattar SBA, Singh S. *Bacterial gastroenteritis in: STAT pearls*. treasure Island (FL): StatSpearls Publishing, 2020.