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,1,2 Innocent Mbulli Ali,1,2 Jude Leinyuy Fonbah,1 Ongbayokolak Sylvie Nadine,1 Solange Dabou,1 Christopher Tume1,3

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 ± SD: 45.0 ± 10.5 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=0.003) 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.

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...
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 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.6 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.3 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 km², it is divided into six subdivisions: Dschang, Santchou, Nkom-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 24 hours, the plates were examined for the presence of characteristic colonies of *Proteus* spp, *Escherichia coli*, *Salmo...
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 performed 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 Enterobacteriaceae; 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             |
| Edwardsiella            |            |                 |
| 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             |

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. $\chi^2$ 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 $34\pm18.77$ 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 $36.19\pm19.68$ years whereas 37.7% (182/556) were male with mean age of $29.48\pm15.88$ 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
| Micro-organism          | Fever | Headache | Nausea | Abdominal pains | Fatigue | Vomiting | Diarrhoea |
|------------------------|-------|----------|--------|-----------------|---------|----------|-----------|
| **Shigella**           |       |          |        |                 |         |          |           |
| *dysenteriae*          | 2.7%  | 2.7%     | 1.2%   | 2.3%            | 4.1%    | 7.5%     | 3.5%      |
| *sonnei*               | 1.2%  | 1.0%     | 1.2%   | 1.5%            | 1.2%    | 1.9%     | 1.3%      |
| *spp*                  | 1.0%  | 0.7%     | 1.2%   | 1.2%            | 1.2%    | 0.0%     | 1.1%      |
| **Citobacter**         |       |          |        |                 |         |          |           |
| *diversus*             | 8.3%  | 9.2%     | 8.6%   | 9.3%            | 6.1%    | 7.5%     | 8.0%      |
| *freundii*             | 2.4%  | 3.4%     | 1.2%   | 2.0%            | 1.6%    | 0.0%     | 1.9%      |
| *spp*                  | 0.5%  | 0.7%     | 1.2%   | 0.3%            | 0.8%    | 0.0%     | 0.5%      |
| **Proteus**            |       |          |        |                 |         |          |           |
| *mirabilis*            | 8.1%  | 6.8%     | 11.1%  | 8.1%            | 8.9%    | 15.1%    | 8.0%      |
| *vulgaris*             | 7.3%  | 8.5%     | 6.2%   | 8.1%            | 8.1%    | 9.4%     | 7.2%      |
| *penneri*              | 1.2%  | 1.0%     | 1.2%   | 1.2%            | 1.2%    | 1.9%     | 0.8%      |
| **Salmonella**         |       |          |        |                 |         |          |           |
| *arizonae*             | 2.7%  | 3.1%     | 2.5%   | 2.9%            | 2.8%    | 1.9%     | 1.9%      |
| *typhi*                | 10.5% | 9.5%     | 12.3%  | 11.0%           | 10.2%   | 11.3%    | 10.6%     |
| *paratyphi A*          | 5.1%  | 4.4%     | 4.9%   | 5.5%            | 5.3%    | 3.8%     | 5.3%      |
| *typhimurium*          | 1.2%  | 1.0%     | 0.0%   | 1.2%            | 1.6%    | 1.9%     | 1.3%      |
| *spp*                  | 2.0%  | 2.0%     | 0.0%   | 2.3%            | 1.2%    | 1.9%     | 1.9%      |
| **Serratia**           |       |          |        |                 |         |          |           |
| *marcesens*            | 2.0%  | 2.4%     | 2.5%   | 1.7%            | 2.0%    | 1.9%     | 1.9%      |
| *odorifera*            | 2.7%  | 2.4%     | 4.9%   | 1.7%            | 2.8%    | 3.8%     | 2.1%      |
| *spp*                  | 1.0%  | 0.7%     | 2.5%   | 0.3%            | 0.8%    | 3.8%     | 0.8%      |
| **Escherichia coli**   |       |          |        |                 |         |          |           |
| *coli*                 | 21.3% | 20.1%    | 16.0%  | 20.9%           | 19.1%   | 3.4%     | 21.8%     |
| **Klebsiella**         |       |          |        |                 |         |          |           |
| *oxytoca*              | 3.4%  | 3.7%     | 2.5%   | 3.8%            | 3.3%    | 3.8%     | 3.5%      |
| *pneumoniae*           | 2.7%  | 2.0%     | 0.0%   | 2.6%            | 2.4%    | 1.9%     | 2.9%      |
| **Edwardsiella**       |       |          |        |                 |         |          |           |
| *hoshinae*             | 3.2%  | 3.4%     | 6.2%   | 3.2%            | 4.1%    | 1.9%     | 3.2%      |
| *tarda*                | 1.2%  | 1.7%     | 1.2%   | 1.5%            | 2.0%    | 0.0%     | 1.3%      |
| **Yersinia**           |       |          |        |                 |         |          |           |
| *Enterococlitica*      | 0.5%  | 0.3%     | 2.5%   | 0.6%            | 0.0%    | 1.9%     | 0.5%      |
| **Providencia**        |       |          |        |                 |         |          |           |
| *rettgeri*             | 4.2%  | 5.1%     | 4.9%   | 4.1%            | 4.9%    | 7.5%     | 4.3%      |
| *stuartii*             | 0.7%  | 0.7%     | 1.2%   | 0.6%            | 1.2%    | 1.9%     | 0.8%      |
| *spp*                  | 1.2%  | 1.4%     | 2.5%   | 1.2%            | 1.6%    | 1.9%     | 1.3%      |
| **Morganella**         |       |          |        |                 |         |          |           |
| *Morganii*             | 1.2%  | 1.4%     | 0.0%   | 1.2%            | 1.2%    | 0.0%     | 0.8%      |
| *Enterobacter geogoviae*| 0.5% | 0.7% | 0.0% | 0.6% | 0.0% | 0.0% | 0.5% |
| **Edwardsiella tarda+Serratia marcescens** | 0.49% | 0.68% | 0.0% | 0.62% | 0.80% | 0.0% | 0.53% |
| **Klebsiella pneumoniae+Proteus vulgaris** | 0.49% | 0.0% | 0.0% | 0.58% | 0.81% | 0.0% | 0.53% |
| **Klebsiella oxytoca+Edwardsiella tarda** | 0.48% | 0.68% | 0.0% | 0.0% | 0.0% | 0.0% | 0.53% |
| **E. coli+Citobacter diversus** | 0.49% | 0.68% | 0.0% | 0.58% | 0.0% | 0.0% | 0.54% |
| **Providencia stuartii+E. tarda** | 0.47% | 0.0% | 0.69% | 0.0% | 0.80% | 1.9% | 0.53% |
| **P value**            | 0.068 | 0.427 | 0.253 | 0.002 | 0.388 | 0.259 | 0.186 |
(0.355 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 *Enterobacteriaceae* 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 microorganisms showed a significant difference with

| 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)   |
| *Serraton 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)  | 50.1 (1)   | 50.0 (1)   |
| P value                | <0.000     | <0.000   | 0.000      | 0.000      |
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 Skyum *et al.*

The distribution of stool type according to microorganisms 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.

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 precluded 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 microorganism 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

| Risk factors                  | Gastroenteritis | Water treatment | Consumption of beverages | Eating out of home | Eating undercook food | Sharing food in the same plate | Eating salad and raw vegetables | Washing vegetables and fruits before used | Types of toilets used | Rearing of bird |
|------------------------------|-----------------|-----------------|--------------------------|--------------------|-----------------------|-------------------------------|-------------------------------|-----------------------------------------|----------------------|---------------|
| **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                 | 1.632                         | 0.973                         |                                         |                      |               |
| Tap water                    | 71.3% (107)     | 28.7% (43)      | 0.562                    | 0.811              | 0.468                 | 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                         | 1.583                         |                                         |                      |               |
| Consumption of beverages     | 86.7% (52)      | 13.3% (8)       | 0.012                    | 4.823              | 2.471*                | 1.102                         | 5.539                         |                                         |                      |               |
| Eating out of home           | 75.6% (235)     | 24.4% (76)      | 0.247                    | 0.297              | 1.140                 | 0.712                         | 1.824                         |                                         |                      |               |
| Eating undercook food        | 75.6% (15)      | 24.4% (3)       | 0.278                    | 0.763              | 1.787                 | 0.486                         | 6.580                         |                                         |                      |               |
| Sharing food in the same plate| 71.9% (64)     | 28.1% (25)      | 0.331                    | 1.385              | 0.717                 | 0.413                         | 1.247                         |                                         |                      |               |
| Eating salad and raw vegetables| 74.0% (248)    | 26.0% (87)      | 0.474                    | 0.329              | 0.869                 | 0.537                         | 1.406                         |                                         |                      |               |
| Washing vegetables and fruits before used | 74.3% (305) | 25.7% (100) | 0.211                   | 0.389              | 1.154                 | 0.735                         | 1.813                         |                                         |                      |               |
| **Types of toilets used**    |                 |                 |                          |                    |                       |                               |                               |                                         |                      |               |
| Latrine                      | 72.2% (296)     | 27.8% (114)     | 0.169                    | NA                 | NA                    | NA                            | NA                            |                                         |                      |               |
| Modern toilet                | 80.1% (113)     | 19.9% (28)      | 4.471                    | 1.723*             | 1.041                 | 2.852                         | 0.034                         |                                         |                      |               |
| No toilet                    | 80.0% (4)       | 20.0% (1)       | 0.228                    | 1.715              | 0.187                 | 15.701                        | 0.633                         |                                         |                      |               |
| **Rearing of bird**          | 79.0% (109)     | 21.0% (29)      | 0.088                    | 4.880              | 0.560*                | 0.335                         | 0.937                         |                                         |                      |               |

* mean statistically significant determinant.
N/A, not available.
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 DDI, 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 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
1Department of Biochemistry, Faculty of Science, University of Dschang, Dschang, West Region, Cameroon
2The Biotechnology Centre, BP 8094, University of Yaounde 1, Yaounde, Centre Region, Cameroon
3Department of Biochemistry, University of Bamenda, Bambili, Cameroon

Twitter Innocent Mbulli Ali @Dr_All_Innocent

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

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