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Trends of potential waterborne diseases at different health facilities in Bamboutos Division, West Region, Cameroon: a retrospective appraisal of routine data from 2013 to 2017

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ABSTRACT

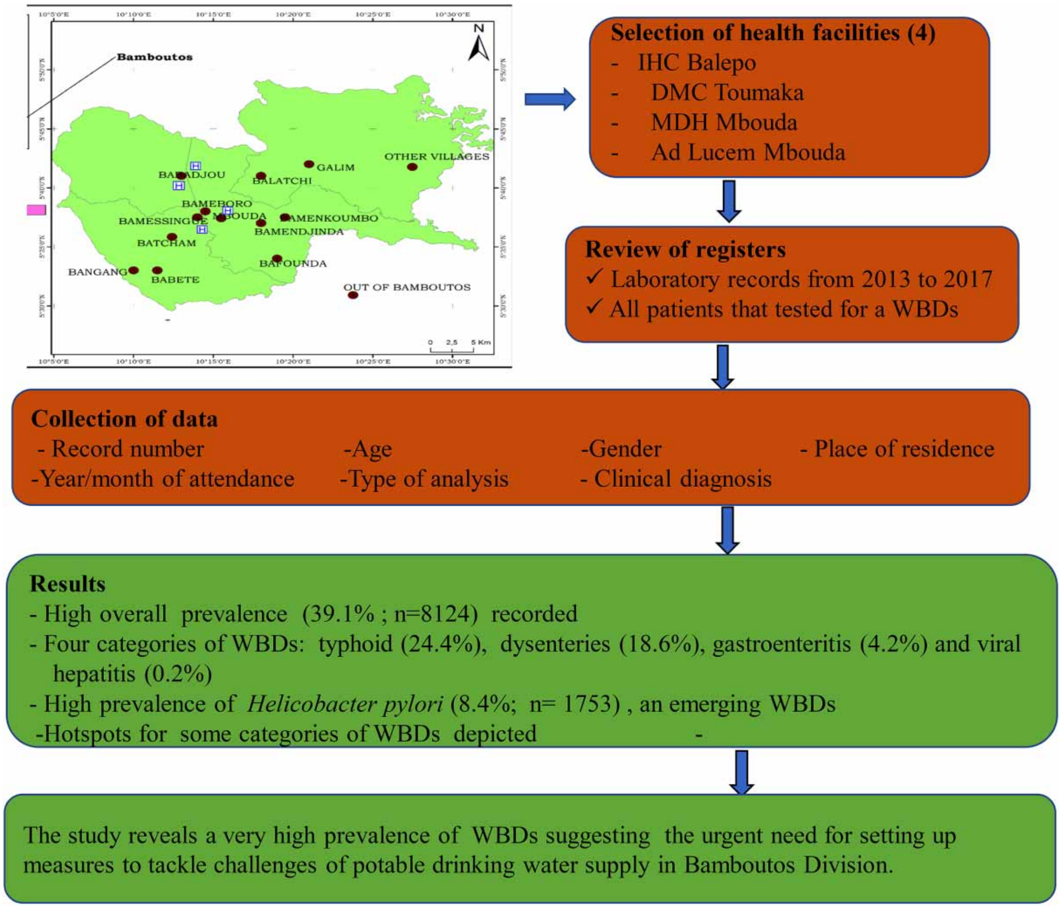
Many Cameroonian cities lack access to potable drinking water where populations rely on alternative water sources of doubtful quality. This study aimed at describing the trends and patterns of waterborne diseases (WBDs) reported in some health facilities in Bamboutos Division between 2013 and 2017 as baseline data towards understanding the profile of WBDs in this area. A retrospective review of clinical data kept on patients who visited the main health facilities in Bamboutos Division from January 2013 to December 2017 was conducted. Overall, 39.1% ($n = 8{,}124$) of total patients were positive for at least one WBD. Categories of WBDs were dysenteries (18.6%), gastroenteritis (4.2%), viral hepatitis (0.2%) and typhoid was the most preponderant (24.4%). The most affected age groups were those above 24 years but significant differences were observed only in 2013 and 2017. Distribution of potential WBDs was locality dependent. The highest prevalence of typhoid fever was recorded in Bameboro (35.4%), dysenteries in Bamedjinda (20.4%) and gastroenteritis (17.3%) in Bamekoumbou. The study shows very high overall prevalence of WBDs in some localities which could be considered as 'hotspots' of WBDs in Bamboutos. This suggests the urgent need for setting up measures to tackle the challenges of potable drinking water supply.

Key words: Bamboutos, Cameroon, dysenteries, gastroenteritis, typhoid fever, waterborne diseases

HIGHLIGHTS

- The study shows an extremely high prevalence of potential waterborne diseases (WBDs). This can be used as baseline data to fight against WBDs.
- High prevalence of *Helicobacter pylori*, an emerging WBDs is an issue of public health concern.
- Spacial distribution of WBDS reveals some vulnerable localities that could be considered as 'foci' for waterborne diseases and used as a guide during epidemiological interventions.

GRAPHICAL ABSTRACT



INTRODUCTION

The quality of water is an issue of public health worldwide. According to the World Health Organization (WHO), 3.4 million people die from waterborne diseases (WBDs) each year, especially children (WHO 2014). The global spatial distribution of WBDs shows that Asia and Africa are the most affected continents. In Cameroon, as in most developing countries with inefficient public health structures, there are challenges in the provision of clean drinking water and good sanitation where residents of rural areas are highly affected compared to their urban counterparts. The WHO states that over 82% and only 42% of the urban and rural populations, respectively, are covered in terms of water supply (WHO 2000). This implies that up to 58% of households in rural areas do not have direct access to drinking water. Due to the privatization of many technical companies, such as SNEC/Camwater in charge of providing good quality water to the population, the supply of drinking water has become a challenge, leaving the affected population at risk. In the absence of adequate public services, the population relies on alternative sources of drinking water, the quality of which is very doubtful (Fonyuy 2014; Nanfack *et al.* 2014; Lontuo-Fogang *et al.* 2020).

Waterborne diseases are diseases caused by direct consumption of water contaminated with pathogenic microorganisms. Contaminated drinking water can be the source of food-borne diseases by ingestion of the same pathogens when it is used in the preparation of food. Most waterborne diseases are accompanied by diarrhoea, involving excessive passing of stools which could lead to dehydration and possibly death. A variety of microorganisms are responsible for these diseases including bacteria, protozoa, viruses and intestinal parasites. Some of the organisms are responsible for numerous waterborne disease outbreaks including *Vibrio cholarae* (cholera), *Entamoeba hystolitica* (amoebic dysentery), *Shigella* sp. (bacillary dysentery), *Cryptosporidium parvum* (cryptosporidiosis), *Salmonella typhi* (typhoid fever), *Giardia* sp. (giardiasis), *Balantidium coli* (balantidiasis), *Campylobacter* (gastroenteritis), rotavirus (diarrhoea), *Escherichia coli* (diarrhoea), hepatitis A virus (liver diseases), hepatitis E virus (liver diseases), *Leptospira interrogans* (leptospirosis) and poliovirus (poliomyelitis) (Cheesbrough 2006; UNICEF 2008; Ako *et al.* 2009; Hulton & WHO 2012; Djomassi *et al.* 2013; Lendzele *et al.* 2017). Cholera has been designated as the most dangerous waterborne infection. Between 2010 and 2011, Cameroon registered outbreaks of cholera with high mortality and morbidity in the northern part (North and Far-North) of the country (Djomassi *et al.* 2013).

Waterborne diseases are well-established public health problems in the West Region of Cameroon, where it has been classified as the second cause of infant mortality and morbidity after malaria in Bafoussam, the capital city of this region (Institut National de la Statistique 2011). However, these diseases account for 40% of the top ten diseases affecting children under five years of age (WHO 2008). Some studies, conducted both in the country and in this region, have shown the low bacteriological quality of drinking water collected from different alternative sources (Ako *et al.* 2009; Temgoua 2011; Fonyuy 2014; Nanfack *et al.* 2014; Nchang 2014). Some studies have equally shown the low quality of water used in vegetable farming (Ntangmo *et al.* 2012), as most waterborne diseases can be transmitted through consumption of raw food or food prepared with contaminated water, while Djomassi *et al.* (2013) focused on the surveillance of cholera epidemics in the country. To the best of our knowledge, the only studies conducted so far on the trends of WBDs are that of Ako *et al.* (2009) in Douala and Nanfack *et al.* (2014) in Mbouda Sub-Division (with only one year's registers explored). Therefore, this paucity of information highlights the necessity for an epidemiological report on the trends of WBDs in the western part of Cameroon. As with many infectious diseases, the range of WBDs changes with demographics. Factors concerning household characteristics (sex, age and locality) in addition to the environment (season and geographical location) may contribute to the incidence of WBDs. As shown in a study recently carried out in Nigeria by Okpasuo *et al.* (2019), poor personal hygiene, poor sanitation, poor knowledge and practice towards drinking water may predispose residents to a high incidence of WBDs. However Lontuo-Fogang *et al.* (2020) reported a low level of knowledge and inappropriate practices in the prevention of WBDs in the study area.

It is in this light that we aimed at describing the trends and patterns of WBDs reported in different health facilities of Bamboutos Division, between 2013 and 2017 as baseline data towards understanding the profile of WBDs in this area. Data generated could play an important role in the evaluation of health care performances and interventions (Clarke *et al.* 2019). This study could equally provide a better understanding of WBDs' profile, such that interventions could be effectively targeted, when and where to anticipate outbreaks, and examine the manner in which health variables vary over time (Okpasuo *et al.* 2019).

MATERIALS AND METHODS

Study site

The study was conducted in four health facilities located within the Bamboutos Division in West Region of Cameroon. These health facilities included the Mbouda District Hospital (MDH), Ad-Lucem Hospital of Mbouda and Integrated Health Center (IHC) of Balepo and the District Medical Center (DMC) of Toumaka, both in the Babadjou Sub-Division. These health facilities receive patients from different communities such as Batcham, Bangang, Bamekoumbou, Bamedjinda, Bamessingue, Galim, Mboudacentre, Babete, Babadjou and others. Bamboutos Division covers a surface area of 1,173 km^2 with about 318,848 residents. It is divided administratively into four councils (Babadjou, Batcham, Galim and Mbouda) and, in turn, into villages (Figure 1). The climate is equatorial with high elevations and moderate-to-high humidity (BUCREP 2010). Rainfall is moderated by the mountains where elevations might reach over 2,000 m with 1,000–2,000 mm rainfall per year with the highest rainfall around the Bamendjing Reservoir. Bamboutos Division experiences four major seasons: the long dry season (LDS) which runs from December to March, a short rainy season (SRS) from March to June, a period of little rainfall (SDS) from June to August and, finally, a long rainy season (LRS) from September to December (https://en.wikipedia.org/wiki/West_Region Cameroon). The main activities carried out in these communities are agriculture, livestock rearing and small-scale business (Lontuo-Fogang *et al.* 2020). This study was conducted in two of these councils: Mbouda and Babadjou.

Study population and design

The study involved a retrospective assessment of routine data kept on patients who visited some health facilities in Babadjou (IHC Balepo and DMC of Toumaka) and Mbouda (MDH Mbouda and Ad-Lucem Hospital) Sub-Divisions. The study population was made up of all patients who visited the health facilities from January 2013 to December 2017 for consultation and conducted any test concerning a WBD.

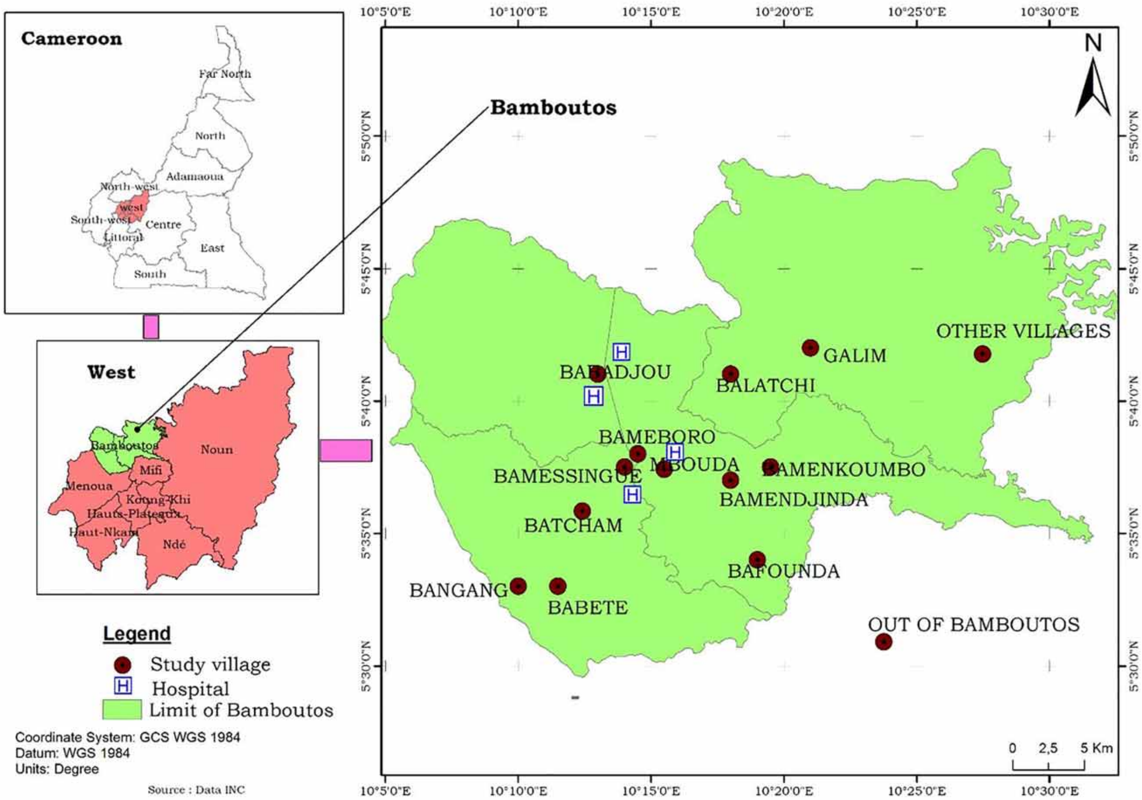


Figure 1 | Study site showing different neighbouring villages and hospitals included during the survey.

Data collection methods and tools

Registers from laboratories were reviewed to obtain clinical diagnosis of all cases during the period. This was done by serially reviewing all the records of patients from January 2013 to December 2017. The data collection device was designed as a listing in the form of rows and columns as described in Osei-Tutu & Anto (2016). Briefly, details such as record number, date (year/month) of visit, sex of patients, age, place of residence, reason for visits, clinical diagnosis, type of analysis and laboratory results (negative/positive or presence/absence) of pathogen tested were the headings of the columns and each row contained the names of patients, but this was not included in the study for reasons of confidentiality. A number was assigned to each patient to replace the names. We included patients that were tested for the following pathogens: *S. typhi* (Widal), *Campylobacter* sp., dysenteries (*Shigella* sp. and *Entamoeba histolytica*), *E. coli*, viral hepatitis (hepatitis A and E), gastroenteritis, *Helicobacter pylori*, *Staphyloccocus aureus, Streptococcus* sp., *Giardia* sp., *Cryptosporidium* sp. and gastrointestinal parasites (*Ascaris* sp., hookworms). The main diseases found were classified into categories of diseases using the International Classification of Diseases (ICD 2019). *H. pylori* was included in this study as an emerging WBD due to its classification by the WHO in the guidelines for drinking water under emerging pathogens in drinking water (WHO 2017). Due to the fact that data were collected from laboratory records, we cannot distinguish whether patients contracted diseases from contaminated drinking water, contaminated food, from person to person or faeco-orally. We therefore consider these routes as possible sources of infection, but more emphasis is laid on the waterborne route because there is the possibility of contracting diseases through the use of contaminated water in food preparation, hand washing and other chores.

Ethical issues

For the better enrolment of the study, permission was obtained from the Regional Delegate of Public Health (reference numbers 0051/L/MINSANTE/SG/DRSPO/CBF) and from the Directors of each health facility. Authorization was also obtained from the Senior Divisional Officer of Bamboutos with reference numbers 004/AR/F.31/SAAJP and an Ethical Clearance finally obtained from the Cameroon National Ethical Committee of Research for Human Health (2019/10/46/CE/CNERSH/SP).

Data processing and analysis

Data obtained from the registers of different health facilities were coded and entered into an Excel spreadsheet. After checking for typing errors and missing values, data were exported into Statistical Package for Social Sciences (SPSS) software version 20.0 for analysis. Pathogens diagnosed were classified into groups of diseases according to ICD10 (ICD 2019). Figures were drawn with Microsoft Excel 2010. Descriptive methods such as frequencies were used to explore characteristics of patients. Ages of participants were categorized in groups while patients who came from localities other than Bamboutos were classified as 'out of Bamboutos'. In the same way, some villages with few patients (Bati, Bagam, Bamendjo, etc.) within Bamboutos were grouped together and referred to as 'other villages in Bamboutos'. Prevalence of the four major categories of potential WBDs was expressed as a percentage of the total number of patients positive during the study period. Prevalence of WBDs was equally compared between localities (place of residence), years, seasons, age and gender over time. Statistical differences from the data were assessed using the χ^2 (chi square) test for categorical variables and analysis of variance (ANOVA) for continuous variables (age of participants). All statistical tests were conducted at the two-sided $P < 0.05$ level of significance.

RESULTS

Demography and diagnostic characteristics of study population

In total, 20,755 patients attending the four health facilities during the period of 2013–2017 were reviewed for this study, consisting of 8,283 (39.91%) in MDH, 4,102 (19.76%) in Ad-Lucem Hospital of Mbouda, 1,771 (8.53%) in IHC Balepo and 6,599 (31.79%) in DMC of Toumaka. Out of the total patients, 10,294 (49.60%) had complete data (age, sex, year of attendance, place of residence and indication of laboratory test/diagnosis) but we included all the patients in the analysis. The place of residence was lacking in most registers of Ad-Lucem hospital and DMC Toumaka. Hospital records varied with the year of attendance ($\chi^2 = 669.6$; $P = 0.0001$). A progressive increase in hospital attendance was observed (2013: 2,804; 2014: 4,134; 2015: 5,365; 2016: 4,242 and 2017: 4,210). The highest attendance was recorded in 2015 where hospital visits reached their peak, then decreased in 2016 and 2017. For the five years, the rate of hospital attendance varied with months ($P = 0.0001$); cumulatively for the five years, the number of records reviewed varied between 1,492 and 1,895 patients per month (or 298–379 patients per month per year). Participants were made up of 8,204 males (39.53%) and 12,551 females (60.47%) with statistical difference ($\chi^2 = 606.5$; $P = 0.0001$). The age varied from less than 1 year to 102 years with the mean age of 39.89 $\pm$ 22.87 years. The mean age varied throughout the study period (ANOVA; $F = 3.84$; $P = 0.004$) (mean (SD); 2013: 41.41 (22.37); 2014: 39.69 (23.07); 2015: 40.00 (22.45); 2016: 39.26 (23.28) and 2017: 39.26 (23.28)) with those from 15 to 44 years recording the highest attendance rate followed by elderly people (>65 years). Most patients came from the Bamboutos Division and villages within the vicinity (Babete, Bamessingue, Balatchi, Galim, Batcham, Bangang, Babadjou, Bameboro, Bamekoumbou, Bamedjinda and Bafounda) (Table 1).

Potential waterborne diseases reported

From 2013 to 2017, 39.1% ($n = 8{,}124$) of patients attending the four health facilities in Bamboutos were found positive for at least one WBD. The clinically diagnosed cases observed during this period were classified into four main groups. Typhoid fever took the lead with a prevalence of 24.4% ($n = 5{,}064$), followed by dysenteries (*Shigella* sp. and *E. histolytica*) with 18.6% ($n = 3{,}859$), then by gastroenteritis (*Ascaris* sp., hookworms, *Campylobacter* sp., *Giardia lamblia* and *E. coli*) with a prevalence of 4.2% ($n = 870$) and lastly viral hepatitis (hepatitis A and E) with 0.2% ($n = 36$). All these were laboratory confirmed cases. The overall prevalence of WBDs were year-dependent ($\chi^2 = 16.55$; df $= 4$; $P = 0.002$) with the highest ($n = 1{,}964$; 46.3%) prevalence recorded in 2016 while the lowest ($n = 1{,}803$; 42.8%) was in 2017. In addition, monthly variations were not observed in the cumulative prevalence of WBDs throughout the study period ($\chi^2 = 10.27$; df $= 11$; $P = 0.51$).

Prevalence of emerging waterborne diseases

Some pathogens have been enumerated by the WHO as emerging WBDs, among which, *H. pylori* is reported in this study with a prevalence of 8.4% ($n = 1{,}753$). However, because this pathogen falls under gastroenteritis in the International Classification of Diseases (ICD 2019), it was grouped together with gastroenteritis in other sections.

Table 1 | Demographic characteristics of study population, 2013–2017

	2013		2014		2015		2016		2017		Total	
Characteristics of patients	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Gender												
Females	1,629	58.1	2,413	58.4	3,238	60.4	2,628	62.0	2,643	62.8	1,2551	60.47
Males	1,175	41.9	1,721	41.6	2,127	39.6	1,614	38.0	1,567	37.2	8,204	39.53
Age (years)												
<5	112	4.4	164	6.2	88	2.1	97	2.5	137	3.3	598	3.4
5–14.	113	4.4	139	5.2	296	7.2	368	9.5	399	9.6	1,315	7.6
15–24	427	16.7	467	17.6	865	21.1	784	20.2	850	20.4	3,393	19.5
25–34	469	18.3	506	19.1	721	17.5	656	16.9	674	16.2	3,026	17.4
35–44	395	15.4	351	13.3	585	14.2	495	12.7	532	12.7	2,358	13.6
45–54	253	9.9	266	10.0	404	9.8	382	9.8	426	10.2	1,731	10.0
55–64	310	12.1	289	10.9	430	10.5	406	10.4	411	9.8	1,846	10.6
>65	481	18.8	466	17.6	720	17.5	702	18.0	744	17.8	3,113	17.9
Place of residence												
Babadjou	608	23.75	419	21.56	512	23.40	492	25.24	592	3,556	2,623	25.45
Babete	49	1.91	86	4.43	163	7.45	170	8.72	75	4.50	543	5.27
Bafounda	10	0.39	29	1.49	69	3.15	65	3.34	47	2.82	220	2.13
Balatchi	27	1.05	26	1.34	36	1.65	36	1.85	28	1.68	153	1.48
Bameboro	16	0.63	30	1.54	49	2.24	48	2.46	35	2.10	178	1.73
Bamedjinda	24	0.94	35	1.80	45	2.06	62	3.18	55	3.30	221	2.14
Bamekoumbou	8	0.31	60	3.09	85	3.88	73	3.75	40	2.40	266	2.58
Bamessingue	158	6.17	205	10.55	291	13.30	265	13.60	206	12.37	1,125	10.92
Bangang	18	0.70	50	2.57	31	1.42	38	1.95	29	1.74	166	1.61
Batcham	26	1.02	54	2.78	65	2.97	39	2.00	41	2.46	225	2.18
Galim	38	1.48	44	2.26	44	2.01	32	1.64	17	1.02	175	1.70
Mbouda	1,400	54.69	821	42.25	667	30.48	494	25.35	336	20.18	3,718	36.08
Other villages	72	2.81	10	0.51	15	0.69	36	1.85	68	4.08	201	1.95
Out of Bamboutos	106	4.14	74	3.81	116	5.30	99	5.08	96	5.77	491	4.76

n, number of positive cases; %, prevalence.

Prevalence of potential waterborne diseases by demographic characteristics

Table 2 highlights the variation of waterborne diseases in the study area by demographic characteristics. The prevalence of WBDs varied with gender, age and place of residence for some years. Significant differences were observed in gender-related prevalence only during the years 2015 and 2016. In 2015, more women ($n = 1{,}439$; 44.4%) than men ($n = 869$; 40.8%) were infected ($\chi^2 = 6.9$; $P = 0.009$). The pattern was similar in 2016 where we recorded a prevalence of 47.6% ($n = 1{,}256$) and 44.2% ($n = 714$), respectively, in women and men ($\chi^2 = 4.45$; $P = 0.035$). As for annual trends in age groups, significant differences were observed in 2013 ($\chi^2 = 32.26$; $P = 0.001$) and 2017 ($\chi^2 = 30.42$; $P = 0.001$) with the highest prevalence recorded in those older than 24 years. Prevalence of potential WBDs was locality dependent in 2013 ($\chi^2 = 119.5$ $P = 0.001$) and 2016 ($\chi^2 = 31.23$; $P = 0.003$) with the highest infection rates recorded in patients who consulted health facilities in Mbouda Sub-Division for both years.

Annual variation of potential waterborne diseases

Figure 2 shows temporal variation of the four categories of WBDs observed during the study. The yearly registered cases of typhoid fever were the highest compared to other diseases throughout the five years but a progressive decrease in clinical

Table 2 | Prevalence of potential waterborne diseases by demographic characteristics per year

	2013 ($n=2,408$)		2014 ($n=4,134$)		2015 ($n=5,365$)		2016 ($n=4,242$)		2017 ($n=4,210$)	
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
Gender	$\chi^2=0.54$; $P=0.46$		$\chi^2=3.41$; $P=0.65$		$\chi^2=6.9$; $P=0.009$		$\chi^2=4.45$; $P=0.035$		$\chi^2=1.18$; $P=0.28$	
Female	730	44.8	1,075	44.6	1,439	44.4	1,250	47.6	1,115	42.2
Males	543	46.2	717	41.7	869	40.8	714	44.2	688	43.9
Age (years)	$\chi^2=32.26$; $P<0.001$		$\chi^2=8.15$; $P=0.32$		$\chi^2=7.3$; $P=0.4$		$\chi^2=5.25$; $P=0.63$		$\chi^2=30.42$; $P<0.001$	
<5	34	30.4	69	42.1	37	42.0	49	50.5	37	27.0
5–14	35	31.0	64	46.0	145	49.0	173	47.0	153	38.3
15–24	207	48.5	237	50.7	432	49.9	380	48.5	362	42.6
25–34	239	51.0	241	47.6	348	48.3	298	45.4	292	43.3
35–44	187	47.3	169	48.1	270	46.2	242	48.9	271	49.1
45–54	122	48.2	131	49.2	174	43.1	197	51.6	193	45.3
55–64	156	50.3	157	54.3	201	46.7	185	45.6	163	39.7
>65	249	51.8	223	47.9	338	46.9	335	47.7	338	45.4
Place of residence	$\chi^2=119.5$ $P<0.001$		$\chi^2=15.82$; $P=0.26$		$\chi^2=16.9$; $P=0.20$		$\chi^2=31.23$; $P=0.003$		$\chi^2=7.13$; $P=0.89$	
Babadjou	181	29.8	182	43.4	227	44.3	199	40.4	283	47.8
Babete	17	34.7	48	55.8	84	51.5	91	53.5	30	40.0
Bafounda	7	70.0	13	44.8	24	34.88	33	50.8	22	46.8
Balatchi	14	51.9	8	30.8	18	50.0	16	44.4	11	39.3
Bameboro	9	56.2	13	43.3	27	55.1	18	37.5	18	51.4
Bamedjinda	11	45.8	14	40.0	23	51.1	29	46.8	26	47.3
Bamekombou	4	50.0	30	50.0	44	51.8	41	56.2	18	45.0
Bamessingue	84	53.2	101	49.3	146	50.2	135	50.9	103	50.0
Bangang	10	55.6	25	50.0	11	35.5	17	44.7	16	55.2
Batcham	15	57.7	27	50.0	29	44.6	15	38.5	17	41.5
Galim	25	65.8	20	45.5	19	40.9	18	56.2	6	35.3
Mbouda	764	54.6	429	52.3	287	43.0	271	54.9	159	47.3
Other villages	34	47.2	5	50.0	8	53.3	20	55.6	37	54.4
Out of Bamboutos	54	50.9	35	47.3	58	50.0	45	45.5	48	50.0

n, number of positive cases; %, prevalence.

cases from 2013 (27%) to 2017 (22.4%) was observed. An opposite pattern was noticed for dysenteries with increased cases from 15.4% in 2013 to 21.4% in 2016 but with a slight drop in 2017 (20.5%). Reported cases of viral hepatitis also increased with time from 0% in 2013 to 0.3% in 2017. A fluctuation was observed in the number of laboratory confirmed cases of gastroenteritis throughout the five years, with the highest prevalence registered in 2013 (13.2%).

Diagnostic method of diseases per health facility

The same laboratory techniques were used in the different health facilities for analysis of WBDs in patients including microscopic examination of stool samples, coproculture, urine cyto-bacteriological test (UCBT), analysis of blood (Widal test), identification of *H. pylori* and hepatitis A and E. It was noticed in Ad-Lucem (a private hospital) that most of their diagnosis was done with antibiogram and it was the only hospital where coproculture was done, and some pathogens like *Shigella* sp,, *Campylobacter* sp,, *G. lamblia*, *Streptococcus* sp. and *E. coli* were recorded only in this health facility. The main pathogens

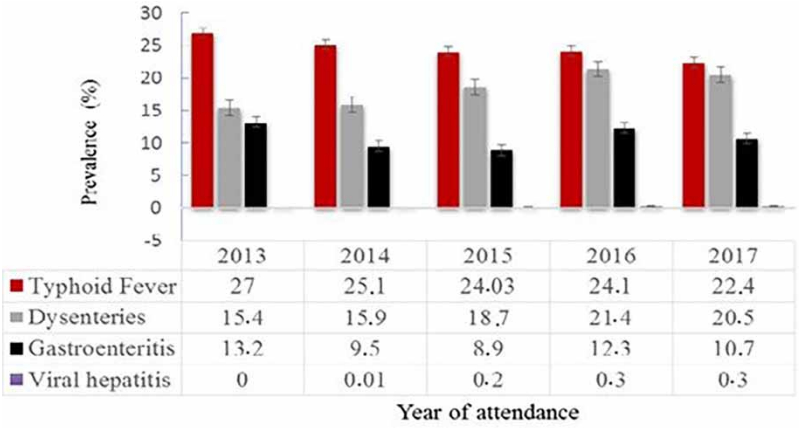


Figure 2 | Prevalence of potential waterborne diseases per annum.

recorded were *Ascaris lumbricoides, E. histolytica,* hookworms, *H. pylori* in addition to other pathogens like *Campylobacter* sp., *Shigella* sp., *G. lamblia* and *E. coli* reported in Ad-Lucem hospital (Table 3).

Seasonality of potential waterborne diseases

Figure 3(a) highlights the variation in the cumulative prevalence of WBDs according to seasons. After reviewing hospital records, it was revealed that the overall prevalence of WBDs was not season dependent ($\chi^2 = 3.6$; df = 3; $P = 0.31$) throughout the five years. Despite the fact that no significant variation was observed in seasons, the highest prevalence ($n = 1{,}545$; 45.5%) was recorded in the short dry season (from June to August) with proportions of hospital visits reaching their peak (32.9%) during the long dry season (from December to March) (Figure 3(b)).

Geographical pattern of each category of potential waterborne diseases

The prevalence of WBDs by locality is presented in Figure 4. Despite the high prevalence in all localities, prevalence of the different categories of WBDs varied significantly within these sites ($\chi^2 = 79.17$; $P = 0.001$). The highest prevalence of typhoid fever was recorded in Bameboro ($n = 63$; 35.4%) while dysenteries were more represented in Bamedjinda ($n = 45$; 20.4%) and gastroenteritis ($n = 46$; 17.3%) in Bamekoumbou. All the cases of viral hepatitis were observed in patients who did not declare their place of residence.

DISCUSSION

The current study aimed at describing the trends and patterns of WBDs reported in different health facilities of Mbouda and Babadjou Sub-Divisions between 2013 and 2017 as baseline data towards understanding the profile of WBDs in Bamboutos revealed important information which could be used to guide the control of WBDs in these localities. The overall prevalence of potential WBDs is extremely high in this study. It is clear that the proportion of the population involved in the

Table 3 | Clinical detection method and pathogens found per hospital

Hospital	Subdivision	Diagnostic method	Pathogens found
Ad-Lucem	Mbouda	Widal, Hp test, stool, UCBT, coproculture (with antibiogram)	*E. histolytica, H. pylori, A. lumbricoides,* hookworms, *S. typhi, Shigella* sp., *Campylobacter* sp., *G. lamblia, Streptococcus* sp. and *E. coli*
MDH	Mbouda	Widal, Hp test, stool, UCBT	*E. histolytica, H. pylori, A. lumbricoides,* hookworms, *S. typhi, G. lamblia*
IHC Balepo	Babadjou	Widal, Hp test, Stool, UCBT	*E. histolytica, H. pylori, A. lumbricoides,* hookworms, *S. typhi*
DMC Toumaka	Babadjou	Widal, Hp test, stool, UCBT	*E. histolytica, H. pylori, A. lumbricoides,* hookworms, *S. typhi*

DMC Toumaka, District Medical Center Toumaka; IHC: Balepo, Integrated Health Center Balepo; MDH, Mbouda District Hospital; UCBT, urine cyto-bacteriological test; Hp, *Helicobacter pylori*.

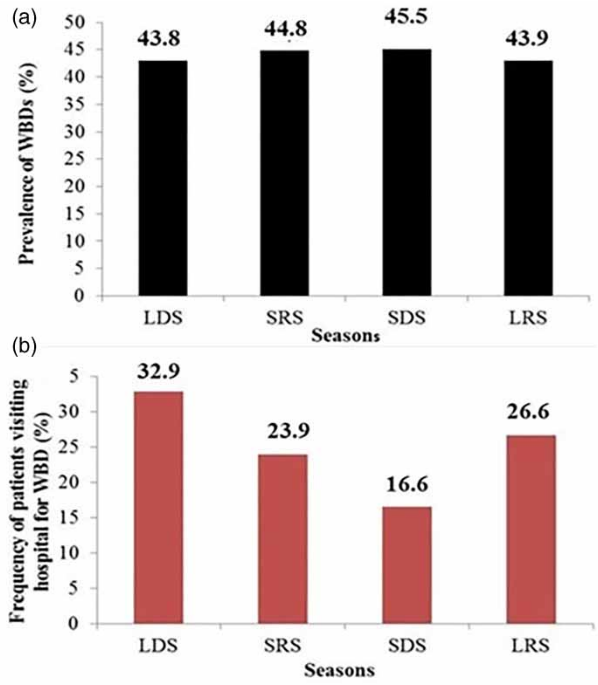


Figure 3 | Prevalence of potential waterborne diseases per season (a) and proportion of patients visiting hospitals per season (b).

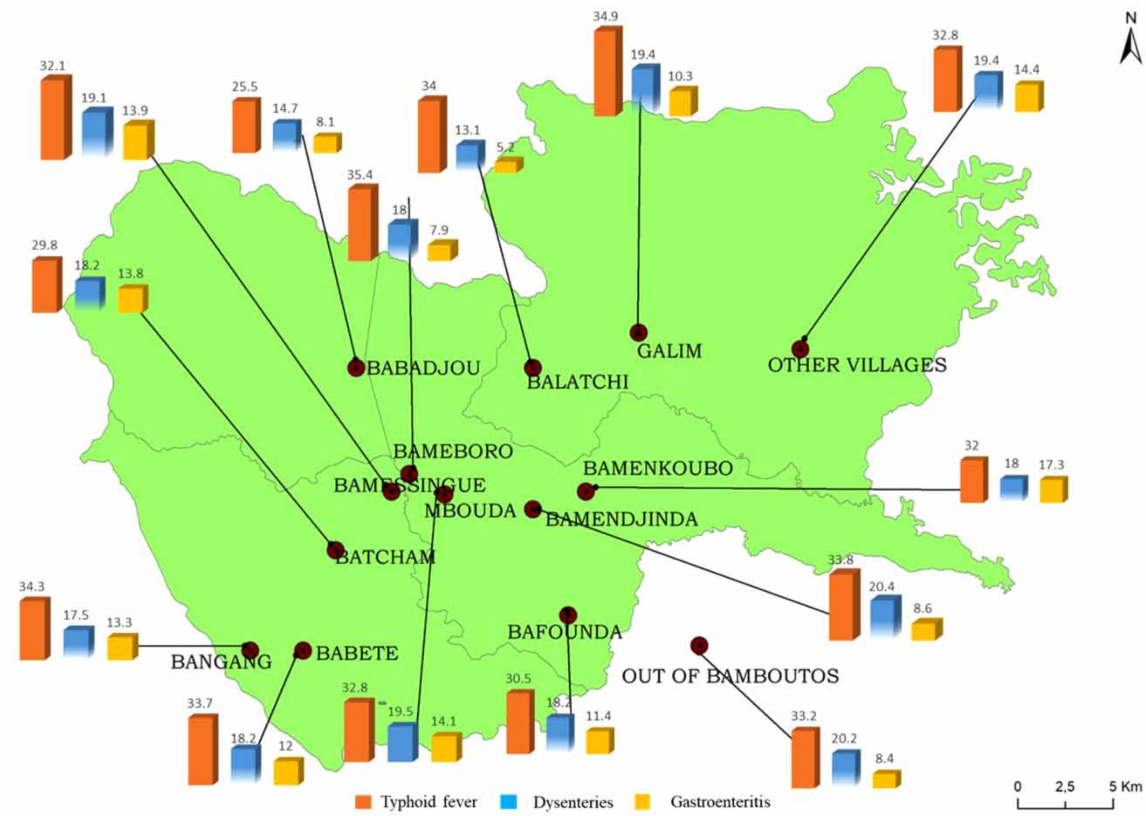


Figure 4 | Spatial distribution of each category of diseases in Bamboutos Division.

study/visiting health facilities are those that are already sick or presenting signs and symptoms of diseases. In addition, other factors like poor personal hygiene, inappropriate food/water hygiene, lack of appropriate medical facilities, especially in rural areas, could be responsible for such high prevalence. However, this prevalence is lower than that obtained in Nigeria by Okpasuo *et al.* (2019) with up to 48.9% for typhoid fever. Review of clinical data revealed typhoid fever, dysenteries, gastroenteritis and viral hepatitis as the main groups of WBDs found in health facilities of the study area. These infections were found to vary with socio-demographic characteristics (gender, age group and locality) at different periods. The different WBDs found in this study are similar to the most common WBDs or food-borne diseases (FBDs) found in health facilities in Cameroon and other countries. A similar study was carried out in the economic capital of Cameroon by Ako *et al.* (2009) and revealed the same diseases in some hospitals in Douala. All the same, Osei-Tutu & Anto (2016) in Ghana observed that cholera, typhoid fever, viral hepatitis and dysentery (shigellosis) were the main diseases (food-borne/waterborne) in the Ridge Hospital in Accra. Okpasuo *et al.* (2019) and Oguntoke *et al.* (2009) in Nigeria also revealed typhoid fever, bacillary dysentery and cholera as the most commonly reported waterborne/food-borne diseases at the health facilities in Nigeria. The prevalence of these WBDs in Bamboutos may be due to lack of knowledge, poor attitude and practice towards the prevention of WBDs among residents, in addition to lack of access to safe drinking water sources (Lontuo-Fogang *et al.* 2020).

The temporal variation of WBDs during the years presented no regular pattern. Typhoid fever was the most reported WBD in this study. All the same, many studies in Cameroon and elsewhere revealed typhoid fever as the most rampant WBD (Oguntoke *et al.* 2009; Yusuff *et al.* 2014; Nanfack *et al.* 2014; Yusuff *et al.* 2014; Okpasuo *et al.* 2019) while Ako *et al.* (2009) identified gastroenteritis in the Doauala 4th District. However, the high prevalence of typhoid fever in this study may indicate that *S. typhi* is the most predominant aetiological agent of waterborne or food-borne diseases of public health importance in villages around the health facilities. In addition, the non-specificity of the Widal test and the possibility of producing positive results a few weeks after treatment (Beyene *et al.* 2008) could account also for its high prevalence as this was the only diagnostic method used in all the health facilities. Furthermore, the fight against this infection is becoming a challenge in sub-Saharan Africa due to its resistance to commonly used antibiotics (Slayton *et al.* 2013) and the common practice of self-medication (Lontuo-Fogang *et al.* 2020) and even drug dependence. The absence of cholera in the clinical records of these four health facilities may indicate their absence or scarcity in the population of Bamboutos Division. Nonetheless, cholera was reported in the West Region during the epidemics of 2010 and 2011, with peaks of up to 245 cases per week, although the Far North, North and Center Regions reported the greatest number of suspected cholera cases in 2011 (Djomassi *et al.* 2013).

Over the five years, more women than men were infected, with important prevalence recorded in adults (>24 years). There is no doubt that women and girls are the most exposed group due to their routine involvement in fetching water and domestic chores. However, to the best of our knowledge, infection with WBDs has not been proven to be gender dependent. High prevalence of WBDs was revealed in adults. Similar results were obtained in Zambia (Mweetwa 2015). This might be related to the fact that the population of Bamboutos Division is highly engaged in farm work and small-scale businesses as their daily activities (Lontuo-Fogang *et al.* 2020), implying that farmers rely on water of unknown quality from streams and other very doubtful sources on the farm while business men, on the other hand, rely either on sachet water or water and food from roadside vendors that might be contaminated. This behaviour is a risk factor for WBDs as Nchang (2014) reported very high bacterial loads in wells in the Bambui and Bambili residential areas while packaged water was reported to be very polluted in a study in Douala (Mananga *et al.* 2014). Surprisingly, children of less than five years old registered low WBD prevalence compared to other groups. This might be due to the poor organization of clinical records in some health facilities, with data on children less than five years old not well documented while the place of residence was completely absent for others. However, Bashiru & Asokan (2016) and Qureshi *et al.* (2011) reported children of less than five years old as the population at risk.

Among the different methods of diagnosis used for the detection of WBDs, AD-Lucem hospital was the only hospital that did coproculture and accompanied most of their tests with antibiograms. This could account for the fact that WBDs like *Shigella* sp., *Campylobacter* sp., *Streptococcus* sp. and *E. coli* were recorded only in this hospital. Despite the fact that the Widal test has been proven to be non-specific and gives positive results for a patient treated after a few weeks, this was the only method used in all the four health facilities for the diagnosis of *S. typhi*. This can be attributed to the fact that the Widal test is relatively cheaper, easy to perform and requires minimal training and equipment (Beyene *et al.* 2008). However, Nsutebu *et al.* (2002) and Wam *et al.* (2019) recommend ELISA technique as a more suitable test for the diagnosis of typhoid fever compared to Widal.

Of all the WBDs identified from hospital records there is no significant variation between seasons, but the highest prevalence was observed in the dry season (short dry season from June to August) and highest number of hospital attendance during the dry season (long dry season from December to March). Similar findings were reported in Nigeria where the occurrence of WBDs peaked during the drier periods of the year and was attributed to water scarcity and depletion of water reserves (Okpasuo *et al.* 2019). This scarcity of water during periods of no rainfall might have left the population with no other choice than to collect water of unknown quality from alternative sources (Lontuo-Fogang *et al.* 2020). This equally implies that water quality assessment should be pronounced in the dry season.

Without taking into account the different years, some localities were vulnerable to particular categories of WBDs. The highest percentage of typhoid fever was recorded in Bameboro, dysentery in Bamedjinda and gastroenteritis in Bamekombou. All these localities are rural areas. One of the possible reasons that could explain why disease prevalence is higher in rural areas could be due to the gap in health care access. However, further investigations are needed and, at the same time, these localities could be considered as foci for these particular WBDs in the study area (Subramanian *et al.* 2017).

CONCLUSION

It is very clear that the overall prevalence of potential WBDs is far too high in the Bamboutos Division, which is a call for concern given the importance of water for the human body. Residents suffer from four main categories of WBDs including typhoid fever, dysenteries, gastroenteritis and viral hepatitis with typhoid being the most preponderant. These infections vary by demographic characteristics for some years, with the highest number of hospital registered cases occurring during the drier periods of the year. Some rural areas were vulnerable to particular WBDs and could be used as 'hotspots' for these diseases during interventions or in guiding interventions to the areas in greatest need. Data gathered from this study could be used as baseline data for the fight against WBDs and understanding the profile of WBDs in the study area. However, because it is uncertain whether patients contracted these diseases through the consumption of contaminated water and food, from person to person, or faeco-orally, further studies are required to verify the quality of drinking water in the study area. As the saying goes, 'prevention is better than cure', we strongly recommend the dissemination of cheap, easy to apply water treatment techniques, such as boiling and filtering, hygienic storing and handling to households.

Limitations

Even though we considered all the data extracted from hospitals records, the poor presentation of data on children under five years, absence of place of residence and age of patients in some health facilities limited the study. The prevalence of reported WBDs in these health facilities may present only the severe cases because a previous study showed that residents of Bamboutos Division practise self-medication in the case of disease.

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

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