Risk Factors associated with a Gastroenteritis Outbreak, Firestone District, Margibi County, Liberia, February 2018

Leroy Stephen Maximore[1,2,&], Maame Amo-Addae[2], Peter Adewuyi[2], Fulton Shannon[2], Himiede Wilson[2], Obafemi Babalola[2], Olayinka Ilesanmi[2], Thomas Nagbe[1]

[1]National Public Health Institute of Liberia, Monrovia, Liberia, [2]Liberia Field Epidemiology Training Program, Monrovia, Liberia

KEYWORDS: Gastroenteritis, Creek water source, Diarrhea, Vomiting, E Coli, Shigella, Liberia

[&]CORRESPONDING AUTHOR
Leroy Stephen Maximore, National Public Health Institute of Liberia, Monrovia, Liberia.
maximoreleroy@gmail.com

RECEIVED
10/12/2019

ACCEPTED
01/12/2020

PUBLISHED
06/06/2021

LINK

https://www.afenet-journal.net/content/series/4/1/8/full/

CITATION
Leroy Stephen Maximore et al. Risk factors associated with a Gastroenteritis Outbreak, Firestone district, Margibi County, Liberia, February 2018 J Interval Epidemiol Public Health. 2021 December; Suppl 1: 8
DOI:
https://doi.org/10.37432/jieph.supp.2021.4.2.01.8

ABSTRACT

Introduction: Gastroenteritis is an inflammation of the intestines that leads to diarrhoea and vomiting. It is one of the commonly reportable diseases in humans and primarily affects children under five years. Globally, gastroenteritis is estimated to result in 1.45 million deaths annually. The burden of gastroenteritis remains exceptionally high in developing counties, especially in areas characterized by poverty. On February 5, 2018, the Margibi County Surveillance Officer received a call from the District Surveillance Officer regarding an outbreak of severe acute diarrhoea from Division 15 and 17 communities of Firestone District. We investigated to confirm the existence of an outbreak, verify the diagnosis, identify risk factors, and institute appropriate control measures. **Methods:** In this study, we defined gastroenteritis as the acute passage of watery or bloody diarrhoea (AWD) of three or more loose or liquid stools within 24 hours (or more frequent passage than is normal for the individual) with or without blood We visited affected and surrounding communities and conducted active case search. The team conducted a 1:1 unmatched case-control study to identify risk factors for developing the illness. We inspected drinking water sources and household water storage facilities. We collected two swabs of freshly passed (< 1 hr) stool samples to identify the causative agent. We established a temporary mobile treatment site in affected communities to treat uncomplicated cases and referred severe cases to Du-side Hospital. We temporarily restrained community dwellers from consuming water from the creek and hand pump. **Results:** We identified and line listed 66 cases, 62 presented with diarrhea and vomiting, but no deaths. Males accounted for 63%, median age of 16 years (range: 2 - 64 years) while 65.1% were age-group over 20 years. Division 15 accounted for 60% of the total number of cases, and 34.8% were admitted at Du-side Hospital. Rubber tappers and students accounted for 36.4% and 31.8% respectively. Drinking water from the creek was 56.0% hand pump 37.9%, while pipe-borne water 6.1%. The overall attack rate was 68 per 1,000 inhabitants. All cases were seen within 24 hours. Community health volunteers identified 35% of the cases while conducting an active case. Drinking water sources, from creek (OR: 6.5 (2.0-21.7), p = 0.00) and hand pump (OR: 6.5 (2.0-21.7), p = 0.00), were significantly associated with being ill and having gastroenteritis. Other significant associated risk factors were working as rubber tapper (OR: 4.0 (1.4-11.7), p = 0.02) and having no formal education (OR: 3.1 (1.10-8.84), p = 0.08). Laboratory analysis isolated E. coli and Shigella sp in the creek water. Six jerry cans of safe drinking water, water guards, hand sanitizers and laundry soap were provided to each household. **Conclusion:** Our findings revealed that the outbreak was due to E.coli infection and Shigella. It was established that the consumption of unsafe drinking water from the creek and hand pumps led to the outbreak. Rubber tappers and no formal education were the possible drivers for the outbreak. However, the daily provision of safe drinking water, rapid case detection and management helped to contain the outbreak quickly without any mortality

Introduction

Gastroenteritis is one of the leading causes of morbidity in humans [1]. Gastroenteritis is an inflammation of the stomach or intestines that causes diarrhea and vomiting [2]. Gastroenteritis can be caused by numerous pathogens such as viruses, bacteria, parasite, and toxins produced by bacteria and poisonous mushrooms [3]. Gastroenteritis can be directly acquired by person-to-person transmissions, consumption of contaminated food or water, contact with contaminated environmental surfaces or fomites (objects) [4].

Globally, gastroenteritis is estimated to result in 1.45 million deaths and 89.5 million disabilities annually [1, 2], of which an estimated 80.3 million cases are attributed to foodborne transmission [4]. The burden of the gastroenteritis in developing countries remains significantly high [5], despite a marked decrease in mortality rates from 4.6 million in 1980 to about 1.5 million annually in 1999 [6]. Several studies have shown that the burden of gastroenteritis remains particularly high in the African continent, especially in areas characterized by poverty [5]. In developing countries, gastroenteritis among children accounts for about 21% of all deaths [7]. Of this, it is estimated that 15-20% or more percentage of community gastroenteritis disease is caused by unsafe drinking water or food [8]. Globally, 780 million individuals lack access to safe drinking water and 2.5 billion lack safe sanitation [9]. Notwithstanding, water has been identified to be the main contributors to gastroenteritis infection and deaths globally [4], especially in rural areas of developing countries [8]. Every day over 5000 children die because of gastroenteritis, 78% of which occur in the African and South-East Asian regions [5]. Gastroenteritis primarily affects children under five years but is usually mild in healthy adults [10]; in most instances, it causes only discomfort and inconvenience [11]. However, it can cause aggressive dehydration and electrolyte imbalances in very ill and weak individuals as well as in very young or old individuals [12].

According to the Liberia Demographic and Health Survey (2013), over 1000 Liberian children under five and the elderly experience gastroenteritis related illness annually from 2012 to 2013 [13]. In 2016, Liberia adopted the Integrated Disease Surveillance and Response (IDSR) system [14], which requires immediate notification of unexplained clusters of health events across all fifteen counties in the country. In every county, all notifiable health events or disease(s) are reported to the County Surveillance Officer by the District Surveillance Officer who receives reports from community and health facility through the Officer-In-charge. On February 5, 2018, Margibi County Disease Surveillance Officer received a call from the District Surveillance Officer regarding a cluster of cases of severe acute diarrhea and vomiting from Division 15 and 17 communities of Firestone District. A rapid response team composed of county and surveillance district officers, county environmental health officer, health promotion officer along with WHO Field Epidemiologist and Firestone Hospital Outreach medical team were deployed, to confirm the outbreak, describe the extent of the outbreak, verify the causative agent identify risk factors, and institute appropriate control measures.

Methods

Outbreak setting

The outbreak occurs in Firestone District, one of the four districts of Margibi County. The District has an estimated population of 73,197 with forty-five divisions or communities namely (Division 1 to Division 45). This District is a rubber concession area that is owned and managed by the Firestone Rubber Plantation Company (FRPC), which gives rise to a massive movement of people in and out of the area for petty trading and other jobs. Majority of the inhabitants are rubber tappers. Every Tuesday is a market day, which draws many people from different communities or divisions converge at Division 15 community to transact business and interact with each other. Divisions 15 and 17 of Firestone District have an estimated 973 inhabitants; Division 15 is two kilometres away from Division 17. The primary source of water for drinking and household use in the divisions is hand pumps and creeks. The Firestone District has one referral Hospital (Du-side Hospital) that is owned and managed by the Firestone Rubber Plantation Management and four Primary Health Care facilities (PHC). The Firestone Plantation Management runs

two of those PHCs while the Government of Liberia runs the other two.

Descriptive epidemiology

Case definition and Case finding

In this study, gastroenteritis was defined as the acute passage of watery or bloody diarrhea (AWD) of three or more loose or liquid stools within 24 hours (or more frequent passage than is normal for the individual) with or without blood. Under the Liberian Integrated Disease Surveillance and Response (IDSR) system, gastroenteritis is prioritized and reportable as either be categorized into acute watery diarrhea (AWD of Cholera) or acute bloody diarrhea (Shigella). The alert threshold for gastroenteritis related illness is one case for AWD or cholera and five or more cases for acute bloody diarrhea in one location at one week or double the weekly reporting average. Therefore, the District Surveillance Officer notified the county when the epidemic threshold was reached, and the investigation was commenced.

To confirm the existence of the outbreak, a case of gastroenteritis was defined as any persons presenting with acute watery diarrhea with or without blood and or vomiting from Division 15 or 17 of Firestone District from February 4 to10, 2018.

The investigation team visited the affected communities (Division 15 and 17), conducted active case search from house to house to identify additional cases, reviewed health records at the Duside Hospital from February 4 to 5, 2018, met the community leaders and conducted awareness in the community to encourage early case reporting.

All identified cases were line-listed and captured information on the date that cases were seen, age, sex, the community or place of residence, date of illness onset, signs, symptoms, history of exposures to contaminated food and water, and outcome of case-patients using the case-based form.

Case management

We established a temporary mobile treatment site to treat uncomplicated cases and referred severe cases (those with dehydration) to Du-side hospital for admission using the hospital ambulance.

Environmental and Laboratory investigation

There are two creeks (one from each division), and five hand pumps in the affected communities (two from Division 15 and three from Division 17). The drinking water sources in the communities and household water storage facilities were inspected. Also, the community environments were further inspected for the presence of open defecation sites and closeness to household use water sources. To identify the probable causative agent of the gastroenteritis, two swabs of freshly passed (< 1 hr) stool samples were collected from 11 cases (five from Division 15 and six from Division 17) whose onset of illness was less than four days and had not used any antibiotics. The samples were transported to the National Public Health Reference Laboratory for testing in Cary-Blair medium and maintained appropriate cold chain mechanisms. Water samples from the two creeks and five hand pumps were collected and analyzed at the National Environmental Laboratory to determine any faecal contamination and whether the chemical, biological and physical parameters acceptable for consumption.

Analytic epidemiology

Case-control study

A ratio 1:1 unmatched case-control study to identify risk factors for developing the illness was conducted. Our study participants were residents of Division 15 or 17 communities of Firestone District. A case of gastroenteritis was any persons presenting with watery diarrhea (with or without blood) and or vomiting from Division 15 or 17 of Firestone District from February 4 to10, 2018. The controls were any resident of Division 15 or 17 of Firestone district who did not present with symptoms of watery diarrhea with or without blood and or vomiting from February 4 to 10, 2018.

A pre-tested interviewer-administered questionnaire was used to interview the cases and controls to obtain socio-demographic information, clinical information (for cases), and potential exposures to contaminated food, water storage and handling practices, hygiene, and sanitation behaviors.

Sample Size for the case-control study

To conduct a 1:1 unmatched case-control study, the sample size was calculated using Openepi application with the assumption that the prevalence rate of gastroenteritis in the exposed group is 60% [16] and level of a significant set at 95% confidence interval (α = 0.05). Therefore, 30 cases and 30 controls were enrolled.

Sampling

Within the communities (Divisions 15 and 17), we followed the chronological order on the line list to select households with cases. In households with multiple cases, only one case was randomly selected by balloting and enlisted in the study until we attained our sample size of 30 cases. We systematically recruited controls from the second household to the left of the case´s household. All members of the household selected for the control, who were not cases were listed, and randomly select one household member as control by balloting and administered the questionnaire on the persons selected.

Study instrument

We used a structured questionnaire, to capture information on variables including age, sex, the community of residence, date and time of illness onset, signs, symptoms, food, water, travel and environmental exposures, and outcome.

Data analysis

Descriptive analysis of frequencies and proportions for persons, place, and time. Frequency tables and figures were done for categorical variables. For continuous variables means, medians, and ranges were calculated. Data were presented in tables and figures. From the descriptive analysis, we generated the hypothesis that exposure the contaminated creek and hand pump water sources is the cause of the gastroenteritis infection transmission in the communities. Therefore, to test this hypothesis, bivariate analysis was done using Chi-square, odd ratio to determine associations between the exposures and dependent variables- the likelihood of having gastroenteritis. To identify predictors of gastroenteritis outbreak, a multivariable analysis was performed. All significant statistical analysis level was set at 95% confidence interval (CI), p-value < 0.05 using Epi Info 7.2 statistical software.

Ethical considerations

The Ministry of Health of Liberia approved to have this outbreak investigated as a public health emergency. Only study participants that agreed to participate in the study were interviewed. All participants signed consent forms before granting an interview. We used unique identifiers to ensure participants confidentiality.

Results

Descriptive analysis

During our investigation, it was confirmed that an outbreak occurred in the two communities (Division 15 & 17). The index case was a 32-year-old lactating mother from Division 17 community who developed signs of diarrhea and vomiting at 11:00 pm on February 4, 2018. However, the index case at Division 15 was a 12-year-old male, and symptom onset was at 1:00 am. Both were admitted on February 5, 2018, at Du-Side Hospital in Firestone District. Thereafter, other persons with similar symptoms of diarrhea and vomiting began reporting and peaked at 2 am on February 5. The investigation and response were initiated by 7:45 am on February 5, 2018. The cases were managed and discharged within 48 hours, with no death reported.

Of the 66 cases identified and line-listed, 62 presented with diarrhea and vomiting, but no deaths. Sixty-three per cent (42/66) of the cases were males; the median age was 16 (range: 2-64) years, and 65.1% (43/66) of cases were in age-group greater than 20 years. Division 15 accounted for 60% (40/66) of the total number of cases reported. Of all the cases, 34.8% (23/66) were admitted at Du-side Hospital. Commonest occupations of the cases were rubber tapping 36.4% (24/66) and 31.8% (21/66) were students. The sources of drinking water were creek 56.0% (37/66), hand pump 37.9% (25/66) and pipe borne water 6.1% (4/66). The overall attack rate was 68 per 1,000 inhabitants. However, the attack rate for Division 15 and 17 communities were 70 and 87 per 1,000 inhabitants, respectively. The epi-curve Figure 1 is typical a point source mode of transmission. All cases were identified within 24

hours. Enhance active case search was initiated with the use of community health volunteers in the affected area, which resulted in the identification and reporting of 35% (23/66) of the cases.

Environmental and Laboratory findings

Open defecation was rampant in both divisions due to the non-functional state of all seven (7) public latrines in Division 15 as well as five out of six in Division 17. Seven different water drinking sources were sampled - two creeks and five water hand pumps. The pH of all the water samples collected was found to be in the normal range, and no chemical contaminant detected. However, the samples showed high levels of turbidity and presence of faecal coliform and *Escherichia coli* were found to be unacceptably high (>50/100ml) in four out of the five drinking water samples tested, which indicates an extremely high contamination level. Shigella species were isolated in six of the 11 stool samples collected. Although the sources of drinking water were creek water 56.0% (37/66), hand pump borehole water 37.9% (25/66) and pipe bore water 6.1% (4/66), but over 92% of cases stored their drinking and domestic water in opened containers and buckets for drinking and domestic tasks. There was no common food eaten during the time of our investigation.

Case-Control Study

Of the 30 cases and 30 controls, the overall median age was 23 (range: 6-58) years. The median age for cases was 27.5 (range: 6 - 58) years, and for the control 20.5 (range: 7 - 47) years, therefore, cases were older than the control and were significant, p = 0.01 (Table 1). Among the cases 66.7% (20/30) were rubber tappers compared to 33.3% (10/30) of the control, p = 0.02 and 56.7% (17/30) cases versus 10% (9/30) control had no education, p = 0.08. There are no significant differences in the sex and marital status of cases and control Table 1.

In Table 2, drinking from the creek water source (OR: 6.5 (2.0-21.7), p = 0.00) was significantly associated with being ill and having gastroenteritis. Other significant associated risk factors were working as rubber tapper (OR: 4.0 (1.4-11.7), p = 0.02), having no formal education (OR: 3.1 (1.10-8.84), p = 0.08), but the age < 26 years was a protective factor (OR: 0.2 (0.06-0.60), p = 0.01) to having gastroenteritis. The exposure to food and sick persons did not associate with having gastroenteritis.

Finally, in Table 3 the predictors of gastroenteritis outbreak in Firestone Districts were creek water as the source of water (OR: 13.8 (2.5-74.2) p = 0.002) and hand pump water source (OR: 9.6 (1.8-51.3), p = 0.008).

Public health actions to control the outbreak

Based on the findings, we educated residents of the communities and rubber plantation farms against drinking water from the creek and contaminated handpumps, by locking all the handpumps. The Firestone Plantation Management treated (chlorinated) the water and constructed an additional eleven handpumps within four days, (six in Division 15 and five in Division 17). The Firestone Plantation Management and Margibi County Health Team provided safe drinking water to each household daily for a week. After a week, those communities were told their water from the handpumps were safe for drinking.

Furthermore, water guards, hand sanitizers and laundry soap were provided by the National Public Health Institute of Liberia and distributed to residents of the affected communities. Two temporary treatment sites were manned by the Firestone Plantation Management, one in each community. Every treatment site had four clinicians and a hygienist. All staff at the treatment site were assigned from the Du-side Hospital. Cases at the treatment site cases were treated with antibiotics such as doxycycline, metronidazole, co-trimoxazole and erythromycin (for pregnant women, lactating mother, and children). Oral rehydration salts (ORS) and analgesic were provided when needed. At the Du-side hospital, cases were treated with normal saline (NS) or lactated Ringer (LR) solution antibiotics. All cases were discharged home with oral medications (oral medicine and ORS).

Discussion

The gastroenteritis outbreak that occurred in Firestone District, February 2018 was likely due to the ingestion of faecal contaminated and unsafe drinking water, with, Shigella isolated among the cases.

Katherine et al. and the Centers for Disease Control and Prevention (CDC) in states bordering the Mississippi River in 2015 made similar observations in an outbreak affecting over 390 persons due to Escherichia coli consumption [15]. In contrast, a study by Karmarkar et al. in Butte and Glenn Counties, California 2018, found out that norovirus infection was the cause of the gastroenteritis outbreak [16].

More males were affected. A plausible explanation is that more males compared to females work in the plantation as rubber tappers, also the study shows relationship between working as a tappers and developing gastroenteritis as such, drinking of water by males was more frequent during tapping. Secondly, the finding that majority of those affected were above twenty years could be explained by the age distribution of the plantation workers exposed to drinking the contaminated water.

Among the cases and controls studied, those with no formal education were more likely to be infected, and this was statistically significant; similarly, a study counted in rural Malaysia, which showed that those no formal education were 2.9 times most likely becoming infected [17].

Limitations

Limitation to our study included the unwillingness of some cases to participate in the investigation.

Conclusion

An outbreak of gastroenteritis was investigated in two communities (Division 15 & 17) in Firestone District of Margibi County, Liberia in February 2018. It was established that the consumption of water contaminated with faecal from the creek and hand pumps was the major contributing factor to the outbreak. Male rubber tappers and no formal education were also identified as possible drivers to the outbreak. Public health interventions of providing an alternative source of safe drinking water, rapid case detection and case management resulted in rapid containment of the outbreak.

Recommendations

In this light, we recommended to the Firestone management to take the following steps to avert future outbreaks; to construct additional hand pumps in both communities and maintain routine water treatment schedule for all 45 divisions to improve the quality of drinking water sources. Additionally, all damaged public restrooms across the 45 divisions should be renovated to discourage open defecation. Finally, in collaboration with the County Health Team, health workers at Du-side Hospital should conduct regular health sensitization among residents of the entire plantation on infectious diseases and personal hygiene.

What is known about this topic

- Gastroenteritis and other diarrhea related diseases are part of the list of immediate notifiable diseases under surveillance in Liberia.
- Usually, there are instances where two to three cases have been reported from Firestone district but not in such large number within a week or a day

What this study adds

- This study provides an understanding concerning the source of the outbreak in Firestone district and its associated risk factors.
- It also identified sanitary gaps faced by the people, which have never been documented.

Competing interests

The authors declare no competing interests.

Authors' contributions

Leroy S. Maximore designed and conducted the study as a resident of Intermediate cohort one, Liberia Field Epidemiology Training Program (LFETP). Mentorship and professional guidance for the design and conduct of the entire research, as well as the development of the manuscript, was provided by Peter Adewuyi, Maame Amo-Addae, Himiede Wilson, Fulton Shannon, Obafemi Babalola, Olayinka Ilesanmi, and Thomas Nagbe. Additionally, those authors also evaluated and

endorsed the final copy of the manuscript after providing their inputs.

Tables and figures

Table 1: Demographic characteristics of gastroenteritis cases and control, Firestone District, Margibi County, February 2018

Table 2: Associated risk exposures to gastroenteritis, Firestone District, Margibi County, February 2018.

Table 3: Predictors of gastroenteritis outbreak, Firestone District, Margibi County, February 2018

Figure 1: Gastroenteritis cases over time, Firestone District, Margibi County, Liberia, February 2018

References

1. Liu Y, Tam YH, Yuan J, Chen F, Cai W, Liu J, Ma X, Xie C, Zheng C, Zhuo L, Cao X, Tan H, Li B, Xie H, Liu Y, Ip D. A Foodborne Outbreak of Gastroenteritis Caused by Vibrio parahaemolyticus and Norovirus through Non-Seafood Vehicle. PLoS One. 2015; 10(9): e0137848.https://doi.org/10.1371/journal.pone.0137848. PubMed | Google Scholar

2. A Vantarakis, K Mellou, G Spala, P Kokkinos, and Y Alamanos. A Gastroenteritis Outbreak Caused by Noroviruses in Greece. Int J Environ Res Public Health. 2011 Aug; 8(8): 3468-3478.https://doi.org/10.3390/ijerph8083468 . PubMed | Google Scholar

3. KE Heiman, RK Mody, SD Johnson, PM Griffin, and LH Gould. Escherichia coli O157 Outbreaks in the United States, 2003-2012. Emerg Infect Dis. 2015 Aug; 21(8): 1293-1301. https://doi.org/10.3201/eid2108.141364. PubMed | Google Scholar

4. Havelaar AH, Kirk MD, Torgerson PR, Gibb HJ, Hald T, Lake RJ, Praet N, Bellinger DC, de Silva NR, Gargouri N, Speybroeck N, Cawthorne A, Mathers C, Stein C, Angulo FJ, Devleesschauwer B, on behalf of World Health Organization Foodborne Disease Burden Epidemiology Reference Group. World Health Organization Global Estimates and Regional Comparisons of the Burden of Foodborne Disease in 2010. PLoS Med. 2015 Dec; 12(12): e1001923.https://doi.org/10.1371/journal.pmed.1001923 . PubMed | Google Scholar

5. World Health Organization. WHO estimates of the global burden of foodborne diseases. Geneva, Switzerland: WHO; 2015. p255.

6. Torgerson PR, Devleesschauwer B, Praet N, Speybroeck N, Willingham AL, Kasuga F, Rokni MB, Zhou X-N, Fèvre EM, Sripa B, Gargouri N, Fürst T, Budke CM, Carabin H, Kirk MD, Angulo FJ, Havelaar A, de Silva N. World Health Organization Estimates of the Global and Regional Disease Burden of 11 Foodborne Parasitic Diseases, 2010: A Data Synthesis. PLoS Med. 2015 Dec; 12(12): e1001920.https://doi.org/10.1371/journal.pmed.1001920. PubMed | Google Scholar

7. SM Fletcher, M-L McLaws, and JT Ellis. Prevalence of gastrointestinal pathogens in developed and developing countries: systematic review and meta-analysis. J Public Health Res. 2013 Apr; 2(1): 42-53.https://doi.org/10.4081/jphr.2013.e9. PubMed | Google Scholar

8. Ameme DK, Alomatu H, Antobre-Boateng A, Zakaria A, Addai L, Fianko K, Janneh B, Afari EA, Nyarko KM, Sackey SO, Wurapa F. Outbreak of foodborne gastroenteritis in a senior high school in South-eastern Ghana: a retrospective cohort study. BMC Public Health. 2016 Dec; 16:564.https://doi.org/10.1186/s12889-016-3199-2. Google Scholar

9. Howard LM, Mwape I, Siwingwa M, Simuyandi M, Guffey MB, Stringer JSA, Chi BH, Edwards KM, Chilengi R. Norovirus infections in young children in Lusaka Province, Zambia: clinical characteristics and molecular epidemiology. BMC Infect Dis. 2017; 17: 92. https://doi.org/10.1186/s12879-017-2206-2. PubMed | Google Scholar

10. SM Bartsch, BA Lopman, S Ozawa, AJ Hall, and BY Lee. Global Economic Burden of Norovirus Gastroenteritis. PLoS One. 2016; 11(4): e0151219. https://doi.org/10.1371/journal.pone.0151219. PubMed | Google Scholar

11. Yong W, Guo B, Shi X, Cheng T, Chen M, Jiang X, Ye Y, Wang J, Xie G, Ding J.. An Investigation of an Acute Gastroenteritis Outbreak: Cronobacter sakazakii, a Potential Cause of Food-Borne Illness. Front Microbiol. 2018; 9: 2549.https://doi.org/10.3389/fmicb.2018.02549. PubMed | Google Scholar

12. G Belliot, BA Lopman, K Ambert-Balay, and P Pothier. The burden of norovirus gastroenteritis: an important foodborne and healthcare-related infection. Clin Microbiol Infect. 2014 Aug; 20(8): 724-730.https://doi.org/10.1111/1469-0691.12722. PubMed | Google Scholar

13. LISGIS Liberia Demographic and Health Survey,20 LISGIS. August 2014. Accessed May 2019.

14. MoH, Liberia. Ministry of Health Liberia National Technical Guidelines for Integrated Disease Surveillance & Response. WHO. 2016. Accessed May 2019.

15. Kotloff KL, Winickoff JP, Ivanoff B, Clemens JD, Swerdlow DL, Sansonetti PJ, Adak GK, Levine MM. Global burden of Shigella infections: implications for vaccine development and implementation of control strategies. Bull World Health Organ. 1999; 77(8): 651-666. PubMed | Google Scholar

16. Ecollan M, Guerrisi C, Souty C, Rossignol L, Turbelin C, Hanslik T, Colizza V, Blanchon T. Determinants and risk factors of gastroenteritis in the general population, a web-based cohort between 2014 and 2017 in France. BMC Public Health. 2020; 20:1146.https://doi.org/10.1186/s12889-020-09212-4 . PubMed | Google Scholar

17. Choy SH, Al-Mekhlafi HM, Mahdy MAK, Nasr NN, Sulaiman M, Lim YAL, Surin J. Prevalence and Associated Risk Factors of Giardia Infection among Indigenous Communities in Rural Malaysia. Sci Rep. 2014; 4: 6909.https://doi.org/10.1038/srep06909. Pub Med | Google Scholar

Table 1: Demographic characteristics of gastroenteritis cases and control, Firestone District, Margibi County, February 2018					
Characteristics	**Case**	**Control**	**Total**	**OR (95% CI.)**	**P-value**
Age < 26 years					
Yes	13 (43.3)	24 (80.0)	37 (61.7)	0.19 (0.06 - 0.60)	0.01
No	17 (56.7)	6 (20.0)	23 (38.3)	Ref	
Sex					
Female	15 (50.0)	15 (50.0)	30 (50.0)	1 (0.36 - 2.75)	1.00
Male	15 (50.0)	15 (50.0)	30 (50.0)	Ref	
Marital status					
No	21 (70.0)	24 (80.0)	45 (75.0)	0.6 (0.20 - 1.91)	0.55
Yes	9 (30.0)	6 (20.0)	15 (25.0)	Ref	
Occupation_ Rubber Tapper					
Yes	20 (66.7)	10 (33.3)	30 (50.0)	4.0 (1.37 - 11.7)	0.02
No	10 (33.3)	20 (66.7)	31 (50.0)	Ref	
No Education					
Yes	17 (56.7)	9 (30.0)	26 (43.3)	3.1 (1.10 - 8.84)	0.08
No	13 (43.3)	21 (70.0)	34 (56.7)	Ref	

Table 2: Associated risk exposures to gastroenteritis, Firestone District, Margibi County, February 2018					
Type of exposures	**Case**	**Control**	**Total**	**OR (95% CI.)**	**P-value**
Creek water source					
No	5 (22.7)	17 (77.3)	22 (36.7)	Ref	
Yes	25 (65.8)	13 (34.2)	38 (63.3)	6.5 (1.97 - 21.7)	0.00
Well water source					
No	27 (49.1)	28 (50.9)	55 (91.7)	Ref	
Yes	3 (60.0)	2 (40.0)	5 (8.3)	1.6 (0.24 - 10.0)	1.00
Hand pump water source					
No	7 (33.3)	14 (66.7)	21 (35.0)	Ref	
Yes	23 (59.0)	16 (41.0)	39 (65.0)	2.9 (0.95 - 8.72)	0.10
Ate food prepared at home					
No	2 (33.3)	4 (66.7)	6 (10.0)	Ref	
Yes	28 (51.9)	26 (48.1)	54 (90.0)	2.2 (0.36 - 12.8)	0.67
Cared for sick person at home					
No	27 (50.9)	26 (49.1)	53 (88.3)	Ref	
Yes	3 (42.9)	4 (57.1)	7 (11.7)	0.7 (0.15 - 3.54)	1.00

Table 3: Predictors of gastroenteritis outbreak, Firestone District, Margibi County, February 2018				
Items	**Exp(B)**	**95% C.I.**		**P value**
		Lower	**Upper**	
Age < 26yrs	0.42	0.083	2.123	0.294
Rubber Tapper	1.02	0.243	4.311	0.974
No education	1.94	0.439	8.583	0.382
Creek water source	13.76	2.554	74.178	0.002
Handpump water source	9.58	1.788	51.281	0.008

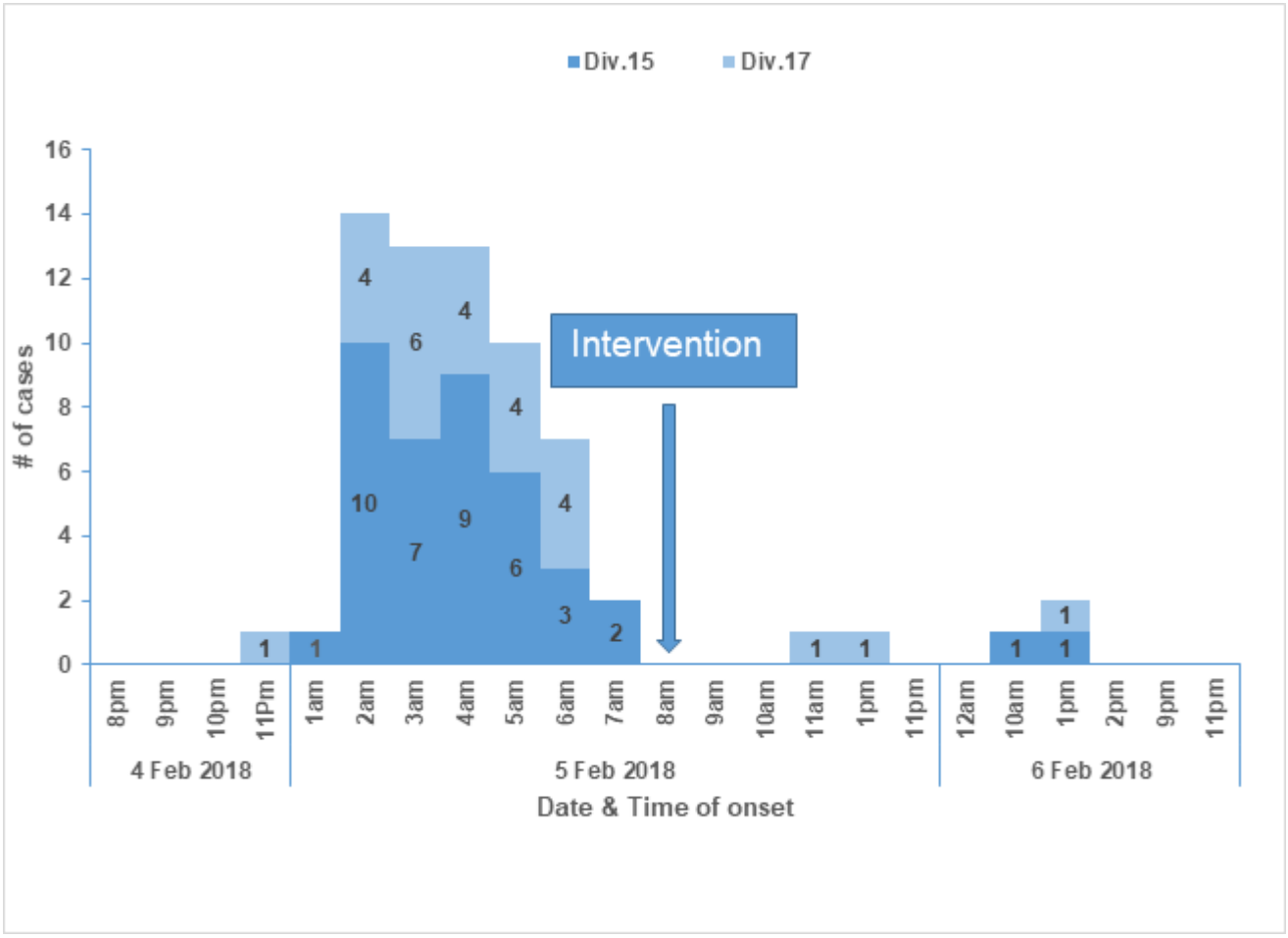

Figure 1: Gastroenteritis cases over time, Firestone District, Margibi County, Liberia, February 2018