Novelty Journals

International Journal of Novel Research in Healthcare and Nursing
Vol. 1, Issue 1, pp: (1-11), Month: September-December 2014, Available at: www.noveltyjournals.com

Cholera Outbreak in Akatsi District of Ghana Caused By Contaminated River after Heavy Rains

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Abstract: **In September 2012, cholera outbreak occurred in Akatsi District of Volta Region, Ghana. We investigated the outbreak to determine the cause and risk factors associated with the outbreak and recommend control measures. We conducted descriptive investigations, active case search and unmatched case control study. We defined a cholera case-patient as a person having acute watery diarrhea, with or without vomiting resident in Akatsi District between 9th and 24th September 2012. Stool from case-patients and water samples were taken for laboratory diagnosis. We performed univariate and vicariate analysis using Epi-Info version 7. Among the 421 cholera case-patients 52.0% were males. The mean age of the case-patients was 32.9 with range between 1-84 years. The age groups 10-19 years (19.0%) and 30-39 years (18.4%) were mostly affected by cholera. Most of the cases of cholera occurred in Wute sub-district where 93.4% of all the case-patients were resident. The Attack Rate was 3.6 per 1000 population. The Case Fatality rate was 1.2% and was higher among females (1.5%). Vibrio cholera serotype Bengal was isolated from stool and river water samples and was unrelated to food.**

Keywords: **Cholera, Ghana, investigation, outbreak, serotype Bengal.**

I. INTRODUCTION

Cholera is a major public health problem in the world today causing recurrent epidemics in developing countries and sporadic outbreaks in developed countries. Cholera is acute intestinal infection caused by toxigenic *Vibrato cholera* serogroup O1 or O139. Infection results in sudden onset of profuse watery diarrhoea, vomiting, circulatory collapse and shock. Estimated 3–5 million cholera cases and 100,000–120,000 deaths due to cholera occur every year[1]. Globally, cholera incidence has increased steadily since the year 2005 with outbreaks persisting in Asia and Africa with estimated 2.5 million cases and 1.3 million cases per year, respectively[2]. More than 90% of the world's reported cases of cholera occur in Africa[3]. Since 1998, cholera outbreaks have been reported consistently from Benin, Ghana, Guinea, and Togo in West Africa[4]. In 2012, 25 countries in WHO Africa region reported cholera outbreaks with 94,553 cases and 1,834 deaths resulting in Case Fatality Rate (CFR) of 1.9%. Among the 25 countries reporting cholera, six of them (DR Congo, Sierra Leone, Ghana, Guinea, Uganda and Niger) accounted for 90% of the total number of cases and 70% of all deaths[5].

Cholera reached West Africa and Ghana during the seventh pandemic[6] and since then cholera has remained endemic[7]. In Ghana, epidemics occur periodically but more in the regions and districts located in the coastal parts of the country. Greater Accra and Central are the most affected regions usually spreading from there to other parts of the country. Cholera outbreaks usually occur at the peak of the rainy and dry seasons[8]. Outbreaks are fuelled by deteriorating waste management in the country, erratic supply of potable water, especially in urban and peri-urban areas, poor food and personal hygiene, and heavy and prolonged rains especially in 2010 and 2011 outbreak[9]. Previously Ghana experienced cholera outbreaks roughly every five years since 1970. However, in recent times, between 2005 and 2012, the country has been experiencing outbreaks almost every year according to the trend in Ghana Health Service annual reports[8, 9].

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Cholera epidemics and deaths that occur are avoidable and amendable to provision of safe water, improvement of environmental sanitation, adoption of appropriate food and personal hygiene. Cholera outbreak had not occurred for many years in Akatsi District, considering the public health importance of the disease; we investigated the outbreak to determine the possible source of infection and implemented control and preventive measures to avert further morbidity and mortality.

II. METHODS

1. Study Area

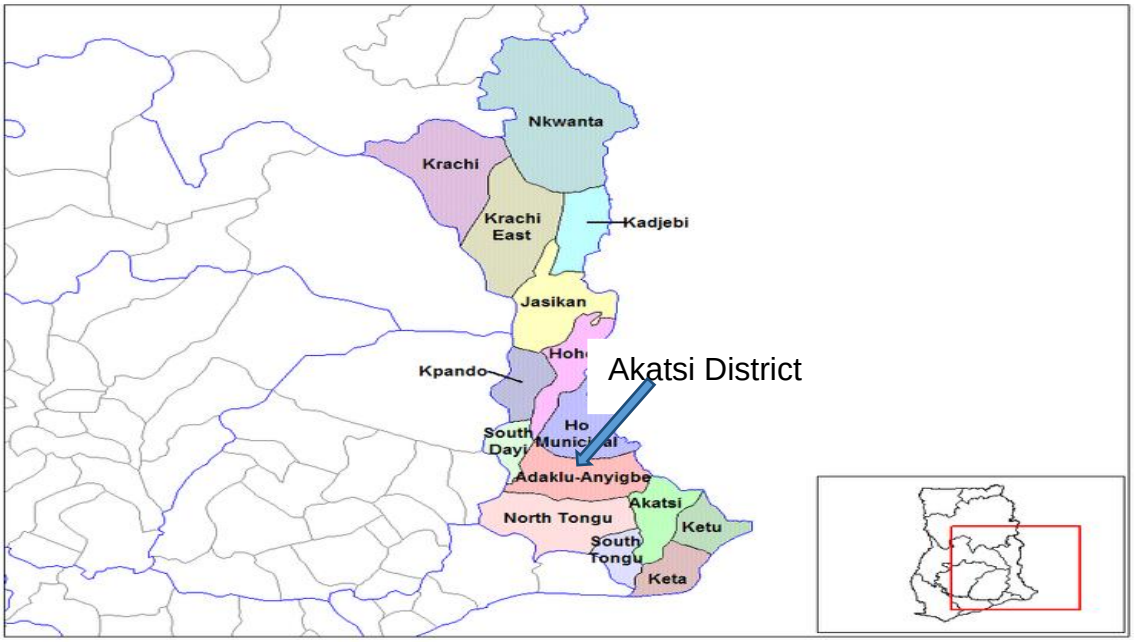

Figure: 1: Showing the map of Volta Region and location of Akatsi District in the region

We conducted outbreak investigation in Akatsi District between 17th and 29th September, 2012. Akatsi District is located in the southern part of the Volta Region of Ghana. It occupies an area of about 906.4 square Km. It shares boundaries with Keta, Adaklu Anyigbe, Ketu and South Tongue districts. The district has five sub-districts namely Akatsi, Avenorpeme, Ave-Dakpa, Wute and Gefia with a total population of 117,164.

There were 20 health facilities in the district, consisting of two hospitals, seven health centers and 11 Community based Health Planning and Services (CHPS) compounds. The disease control system in the district was run by the Disease Control Unit of Ghana health Service and the Environmental Health Unit of the District Assembly. The Disease Control Unit in District Health Directorate of the Ghana Health Service was responsible for investigation and control of outbreaks of communicable diseases, surveillance of reportable diseases and providing health education and materials to reduce the effect of outbreaks.

The main occupation of the people of the district were farming and trading. Akatsi district had two rainy seasons, the major season was from March to June and the minor season, from September to October. The dry season in Akatsi district was between Novembers to March. The main river in the district was river Tordzi and there were numerous dams created for agricultural purposes. River Tordzi also served as a source of drinking water for communities along its banks as it passes through the district. The vegetation of the area is mainly savanna type with low lying forest in some areas.

Majority of the people affected during the outbreak were from Wute sub district with most of their communities along River Tordzi. The cholera outbreak in Akatsi was preceded by outbreaks in Adaklu Anyigbe and North Tongu districts in communities upstream of River Tordzi in September, 2012.

2. Study Design:

***2.1 Descriptive Epidemiology*:**

We interviewed key informants in the district to obtain information on the outbreak and preliminary data on those who were affected. We reviewed the surveillance data and line list. We defined a cholera case-patient as a person having acute watery diarrhea, with or without vomiting. Additionally, we also defined cholera case-patient as a person with vibrio cholera isolated from stool sample or epidemiologically linked to a person with vibrio cholera isolation in Akatsi District between 9th and 24th September 2012. We reviewed medical records from the Akatsi District and St Paul's Hospital and all the health facilities in the district looking for cases that met the case definition. A line list of all the cases were made and information on age, sex, place of residence, date of onset, date of presentation at health facility and outcome were collected. Active case search and community interviews were conducted to trace other cases and contacts in order to obtain information on what cause the outbreak to inform hypothesis generation.

2.2. Analytical Epidemiology:

We conducted unmatched case control study to determine the cause of the outbreak. Sample size was determined using Stat cal utility feature of Epi Info 7 statistical software. A minimum sample size of 154 was estimated consisting of 77 cases and 77 controls, using a confidence level of 95%, power of 80%, expected exposure frequency in controls of 5%, case to control ratio of one and odd ratio of 4 (for a risk factor on which intervention would have a significant impact).

A case was defined as a person with acute watery diarrhea with or without vomiting resident in Akatsi District from 9th to 24th September, 2012. Controls were persons resident in the same area with case-patients without acute watery diarrhea within the same period. Eighty case-patients were randomly selected from the line list and traced by their addresses to their various communities and interviewed using a structured questionnaire. Neighbors of cases who were not ill during the same period were selected as controls. Information collected included age, gender, occupation, education, food history, water source and quality. Clinical information on case-patients were also obtained.

We designed structured questionnaire which was pretested in the District Hospital. Three field workers were selected and trained to administer questionnaires to both cases and controls. Demographic information and potential food and water exposures and hygienic practices from 9th September to the interview date were ascertained. The case-patients were also interviewed pertaining to their clinical presentation and treatment received at the health facility.

2.3. Laboratory Investigation:

Stool samples were collected from case-patients and water samples collected from River Tordzi were sent to the Volta Regional Hospital Laboratory at Ho. The stool samples were transported in Clairy-Blair transport media and plated on Thiosulphate Citrate Bile Salt (TCBS) agar. The water samples were directly inoculated on TCBS agar. Colonies of growth were evaluated using standard biochemical methods. Positive Vibrio cholera isolates were serogrouped and serotyped using agglutination tests with commercial anti-sera.

2.4. Environmental Survey:

After reviewing the descriptive data and hypothesis generation interviews the outbreak pointed to contaminated water source. We visited the communities where most of the case-patients were coming from to determine water sources, quality water, environmental sanitation and drainage. Four random water samples from River Tordzi, the main water source for case-patients in four communities along river were taken for culture for Vibrio cholera serogroup O1 and O139. Both cases and controls were also interviewed about their source of water supply and quality.

2.5 Ethical Consideration:

The study was implemented in collaboration with the district health officials after obtaining authorization. The verbal consent were obtained from the cases and controls. Privacy, confidentiality and rights of patients were ensured during and after the conduct of the study. Oral informed consent was obtained from each case and control after detailed explanation of the existence of the outbreak, the objective of the study and the planed use of the information. The information was entered and analyzed anonymously.

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2.6 Data Analysis:

Data collected was entered into Epi Info 7 software, cleaned and analyzed. We performed descriptive analysis of the outbreak data in time, person and place. We used frequencies, percentages and rates to express univariate analysis. In the case control study, vicariate analysis was done to identify potential risk factors using Chi-Square test at 95% confidence level or alpha-level of 5%. An exposure was considered a risk factor if the odds of association with cholera-case status at 95% confidence interval was statistically significant based on a p-value of <0.05 and confidence interval does not include one.

III. RESULTS

1. Descriptive Epidemiology:

The distribution of diarrhea diseases in Akatsi District between 2010 and 2012 showed an increase from February-July over that of 2010 and 2011 during the same period. The increased was highest in September 2012 (Figure 1), when the cholera outbreak occurred.

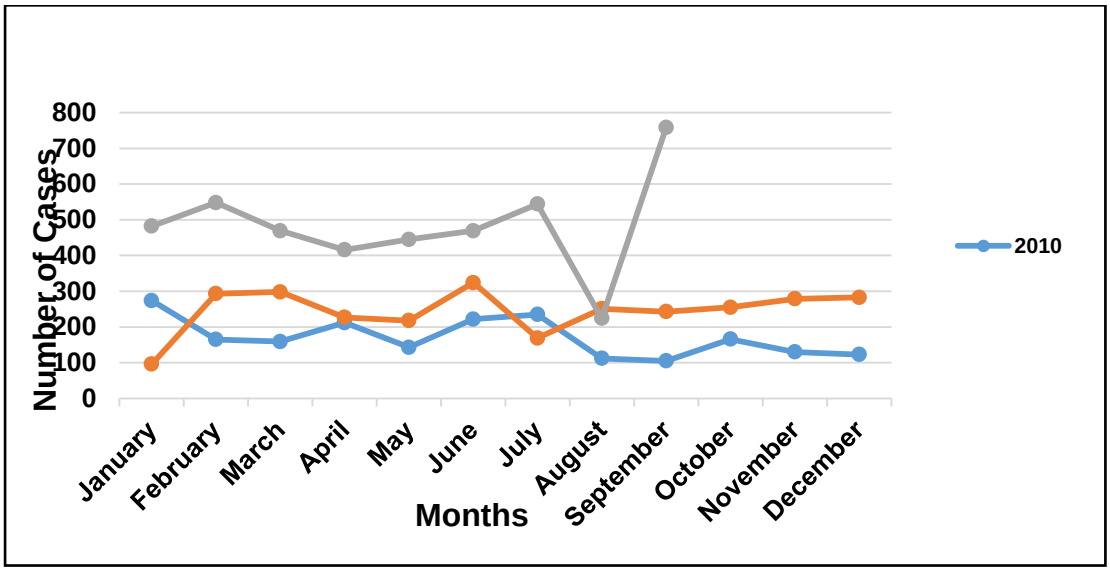

Figure: 2 Trend of diarrhea diseases in Akatsi District, 2010-2012

The index case was 58 years old man from Kpevi community who reported to Akatsi District Hospital on the 9th September 2012. He was taken to Hospital by his 19 years old son, a Senior High Secondary School student, who heard his father was sick while in school. The boy became ill within 48 hours after drinking water in the home from River Tordzi and was also admitted at the same hospital on 11th September, 2012. Stool samples taken from both father and son was positive for Vibrio cholera serogroup O139 (Bengal) for only the boy. The index case had received antibiotics for 72 hours before stool sample were taken. Between 9th and 23rd September 2012, a total of 421 cholera case patients were seen in the health facilities in the district, out of which 52.0% were males. The mean age of the case-patients was 32.9 with range between 1-84 years. The overall attack rate was 0.36% (3.6 per 1000 population). The sex specific attack rates were 0.40% and 0.33% for males and females respectively. During the outbreak five died from cholera, among which were three females. The case fatality rate was 1.2%.

We observed a point source epidemic as shown in Figure 2 with peak incidence on 15th September, 2012. The outbreak commenced on 9th September with gradual increase of cases from 12th September to 15th September, followed by sharp decline of cases by 23rd September.

Figure 3 shows that more males were affected than females. The age groups 10-19 years (19.0%) and 30-39 years (18.4%) were mostly affected by cholera. The least affected age group was 80-89 years (3.0%). Most of the cases of cholera occurred in Wute (29.3%).

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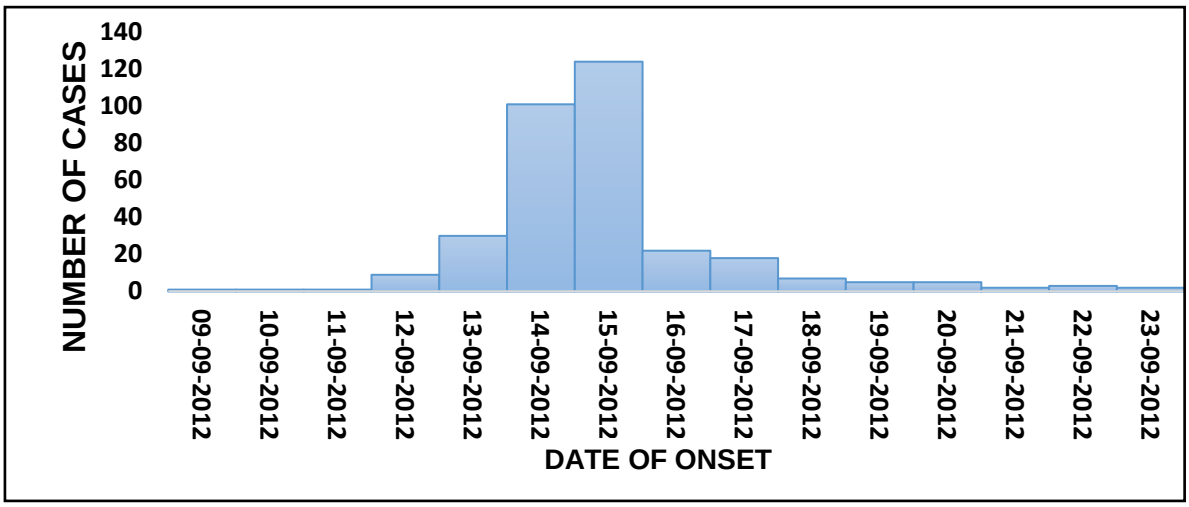

Figure: 3 Distribution of cases of cholera by age and sex in Akatsi District, September 2012.

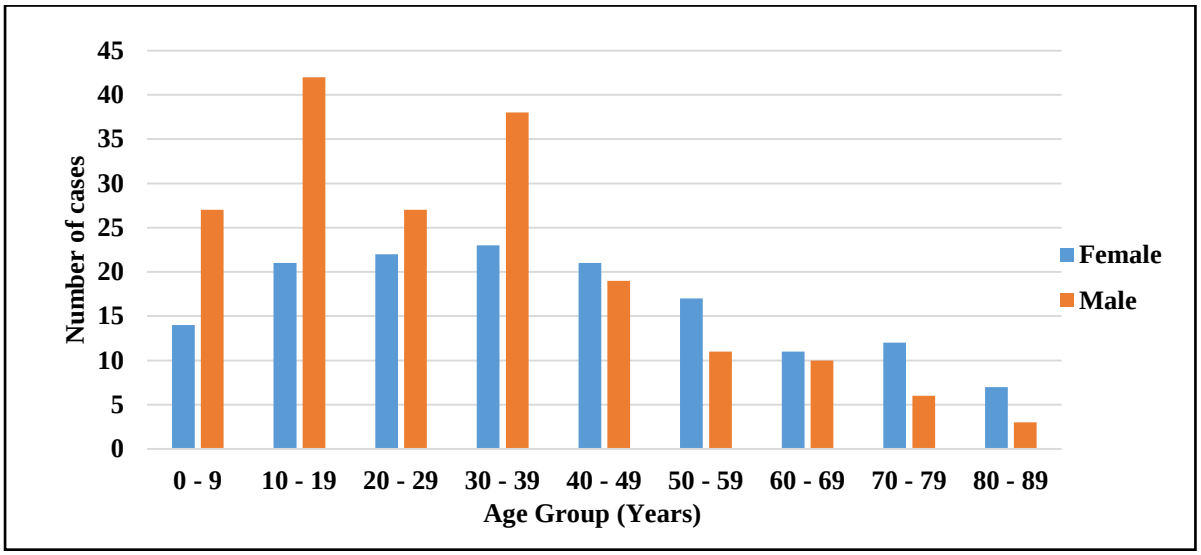

Figure: 4 Distribution of cases of cholera by age and sex in Akatsi District, September 2012.

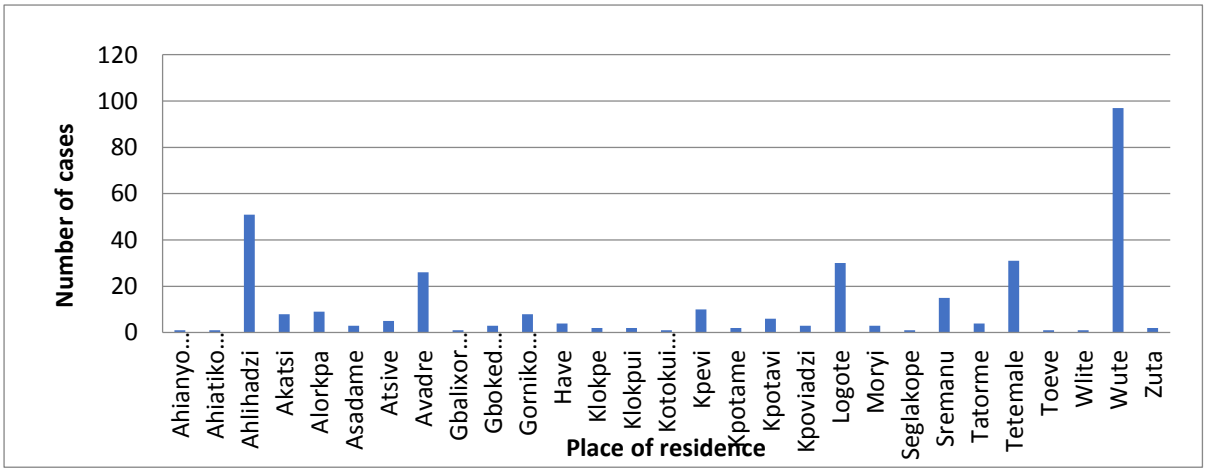

Figure: 3 Distribution of cases of cholera by place of residence in Akatsi District, September 2012

2. Analytical Study

We enrolled a total of 160 participants in the case control study consisting of 80 cases and 80 controls. The cases included 56.3% females and 43.8% males, and controls were made up of 51.3% females and 48.8% males. The cases and controls were similar in terms of sex (X^2=0.23, p=0.63). The mean age of the cases was 39.5 years and that of controls was 40.0 years. The age range among the cases was between 4 - 89 years and that of the controls 7 - 84 years. The cases and controls were comparable in terms of age (X^2=11.2, p=0.08).

Majority of the cases (66.3%) and controls (61.3%) had some education. Cases and controls were significantly different in their educational status (X^2=3.91, p<0.05). Most of the cases (73.8%) and controls (87.5%) were employed. According to employment status, the cases and control were significantly different (X^2=4.0, p<0.05).

All cases presented with diarrhea, with 43.8% also presenting with vomiting. Most of the cases (60.0%) reported a day after onset of illness. Majority of the cases, 83.8% did not use any medication at home and those who had treatment at home used Oral Rehydration Salts (ORS). About 50.0% of the cases had severe dehydration and 23.8% had some dehydration.

Table: 1 Showing demographic characteristics of the cases and controls

	Cases N=80 (%)	**Controls N=80 (%)**	**Odds Ratio(CI)**	**X^2**	**P-value**
Sex					
Male	35(43.75)	39(48.75)	0.82	0.23	0.63
Female	45(56.25)	41(51.25)			
Age					
Mean	39.5	40.0			
SD	23.5	17.1			
<10	5(6.25)	2(1.25)		11.24	0.08
10-19	15(18.75)	6(7.25)			
20-29	9(11.25)	13(16.25)			
30-39	14(17.50)	18(22.50)			
40-49	11(13.75)	22(27.50)			
50-59	7(8.75)	6(7.25)			
60+	19(23.75)	13(16.25)			
Education					
No Education	27 (33.75)	15 (18.75)	2.21 (1.07-4.57)	3.91	0.048
Some Education	53 (66.25)	65 (61.25)			
Nil	27(33.75)	15(18.75)		5.44(3)	0.14
Primary	34(42.50)	40(50.00)			
JHS	17(21.25)	24(30.00)			
SSS	2(2.50)	1(1.25)			
Occupation					
Unemployed	21(26.25)	10(12.50)	2.49 (1.09 - 5.71)	4.00	0.045
Employed	59(73.75)	70(87.50)			
Village of Residence					
Kpevi	6(7.50)	6(7.5)		0.65	1.00
Logote	15(18.75)	12(15.00)			
Sremanu	7(8.75)	9(11.25)			
Tetemale	7(8.75)	8(10.00)			

Wute	22(27.50)	22(27.50)			
Ahlihadzi	9(11.25)	9(11.25)			
Avadre	14(17.50)	14(17.50)			
Household Size					
Mean	3.40	3.59			
SD	1.76	1.45			
1-4	63(78.75)	59(73.75)	1.32(0.63-2.74)	0.31	0.58
5-8	17(21.25)	21(26.25)			

At the health facility majority of the cases, 95.0% were treated with ORS, 58.8% received intravenous infusions and 88.8% were treated with oral Doxycycline.

Table: 2 the clinical presentation, treatment received by case-patients and outcome of cholera in Akatsi District, September 2012

Variables		**Number N=80**	**%**
Symptoms of illness			
Diarrhea	Yes	80	100.0
	No	0	0.0
Vomiting	Yes	35	43.75
	No	45	56.25
Cramps in Abdomen	Yes	1	1.25
	No	79	98.75
Cramps in arms and legs	Yes	0	0.0
	No	80	100.0
Duration of illness before reporting for treatment/Days	Mean	1.60	
	SD	0.91	
	1	48	60.0
	2	21	26.25
	3	8	10.00
	4	1	1.25
	5	2	2.50
Treatment given at home	Yes	13	16.25
	No	67	83.75
Signs on Presentation			
Dehydration	Nil	19	23.75
	Some	21	26.25
	Severe	40	50.00
Fever	Yes	0	0.0
	No	80	100.0
Treatment given at health facility			
Oral fluids	Yes	74	95.00
	No	6	5.00

IV fluids	Yes	47	58.75
	No	33	41.25
Tetracycline	Yes	9	0.00
	No	71	88.75
Doxycycline	Yes	71	88.75
	No	9	11.25
Co-trimoxazole	Yes	0	0.00
	No	80	100.00
Outcome of illness	Improved	80	100.00
	Died	0	0.00

Table: 3Showing food history of cholera case patients within five days before the onset of cholera outbreak

Risk Factors	Cases N=80 (%)	Controls N=80 (%)	Odds Ratio(CI)	X^2	P-value
History of eating outside within the past 5 days	0/80	0/80	Undefined	Undefined	
Hot Kenkey	3/80	3/80	1.00 (0.20-5.11)	0.17	0.68
Cold Kenkey	0/80	1/80	0.00(Undefined)	0	1
Hot fried fish	0/80	0/80	Undefined	Undefined	
Cold fried fish	3/80	2/80	1.52 (0.25-9.35)	0	1
Hot banku	74/80	78/80	0.32 (0.06-1.62)	1.18	0.28
Cold banku	0/80	0/80	Undefined	Undefined	
Hot soup	21/80	25/80	0.78 (0.39-1.56)	0.27	0.6
Cold soup	0/80	0/80	Undefined	Undefined	
Hot rice	6/80	5/80	1.22 (0.36-4.16)	0	1
Cold rice	0/80	1/80	Undefined	0	1
Hot stew	7/80	5/80	1.44 (0.44-4.74)	0.09	0.76
Cold stew	0/80	1/80	0.0 (Undefined)	0	1
Hot koko	12/80	13/80	0.91 (0.39-2.14)	0	1
Cold koko	1/80	0/80	Undefined	0	1
Hot bread	1/80	0/80	Undefined	0	1

Cold bread	3/80	4/80	0.74 (0.16-3.42)	0	1
Hot bofrot	0/80	0/80	Undefined	Undefined	
Cold bofrot	0/80	0/80	Undefined	Undefined	

In terms of the exposures studied, as indicated in table 3 and 4, cases and controls were similar (95% CI includes 1, p>0.05). None of the cases and the controls had history of eating food outside within five days before onset of illness of a case-patient. Most of the cases and the control ate hot banku (74/80 and 78/80 respectively), and hot soup by 21/80 of cases and 25/80 of controls. There was no significant difference between the cases and control in terms of eating hot banku and hot soup. Cold food was generally not preferred choice of both cases and controls.

Table 4 Risk factors of cholera examined among cases and controls

Risk Factors		Cases	Controls	Odds Ratio(CI)	X^2	P-value
		N=80 (%)	N=80 (%)			
Diarrhea Contact at home	Yes	1(1.25)	1(1.25)	1.00(0.06-16.27)	0.51	0.48
	No	79(98.75)	79(98.75)			
Availability of Pit latrine	Yes	50(62.50)	47(58.75)	1.17(0.62-2.21)	0.1	0.75
	No	30(37.50)	33(41.25)			
State of Latrine	Clean	47(94.00)	42(89.36)	1.87(0.42-8.28)	0.21	0.65
	Dirty	3(6.00)	5(10.64)			
Water Source	River	80(110.0)	79(98.75)	0.00(Undefined)	0.5	1.00*
	Borehole	0(0.00)	1(1.25)			
Home cleanliness	Yes	1(1.25)	0(0.00)	Undefined	0	1.00*
	No	79(98.75)	80(100.00)			
Health education on diarrhea received within last 2 years	Yes	0	0	Undefined	undefined	
	No	80	80			
Knowledge of cause of cholera	Know	28(32.94)	31(36.47)	0.86(0.45-1.61)	0.1	0.75
	Don't Know	57(67.06)	54(63.53)			

*Undefined

3. Environmental Assessment

Most of the communities visited were clean and have latrine for use, but have no facility for hand washing after using latrine. Majority of the communities affected were along the banks of the River Tordzi and depended on the river for water for domestic use. No epidemic had occurred in Akatsi District in these communities previously.

Among the communities along the banks of River Tordzi with access to functional boreholes like Kpevi, Tetemale and Sremanu abandoned their use claiming the borehole water was salty. Tetemale had filtration units that were built in the community for filtering the river water. However, the community found the process labourious and had abandoned the use of the filtration plant and was drinking water from the river raw without any treatment. The communities were educated during durbars and on the radio station in the district to use borehole water and boiled river water before drinking and use domestically. Evaluation showed that this information was accepted and used by the communities.

The epidemic of cholera occurred during the minor raining season when the water in the River Tordzi was found dirty. Four samples of water randomly taken from river at Kpevi, Moryi, Tetemale and Avadre was positive for Vibrio cholera O139 at Moryi. The other three samples grew Enterobactor aero genes (Avadre), Pseudomonas aeroginosa (Kpevi and Tetemale) and Klebsiella oxytoca (Tetemale).

4. Laboratory Results

Two of the stool samples taken to the Regional Laboratory for culture and identification confirmed Vibrio cholera serogroup O139, serotype Bengal. Only one of the four water samples also confirmed Vibrio cholera serotype Bengal. The rest of the water samples grew gram negative bacteria.

IV. DISCUSSION

The cholera outbreak in Akatsi District was a water borne point source outbreak caused by V. *cholera* serogroup 0139 serotype Bengal. Almost all the cases and controls depended on River Tordzi for water for domestic use. One of the water samples from river isolated *Vibrio cholera* serogroup O139, serotype Bengal. The outbreak occurred during the second raining season when the river was dirty and contaminated possibly from faecal matter carried by the run offs into the river. This was confirmed by isolation of different types of enteric pathogenic bacteria from the three other water samples from the river. Cholera infection was acquired by drinking water from the river without boiling or appropriate treatment. Some of the communities affected by the cholera outbreak had boreholes, but were depending on the river water, the borehole water was considered salty. Even though the community had been using the river water, cholera outbreak was previous unknown. Obviously contamination of the river during the raining season was responsible, therefore, immediately health education intervention was initiated, the outbreak was brought to abrupt end within two weeks.

Contamination of water is one of the main sources of cholera outbreak especially in communities where portable water is unavailable. Communities along the river have poor sanitation and personal hygienic practices, and lack of toilet in residences. Faecal contamination of rivers following rainfalls is possible. The World Bank estimates that about 16 million Ghanaians use unsanitary or shared latrines and 4.8 million lack latrines and defecate in the open[11]. This unsanitary practices lead to contamination of the river on which the people depended on for domestic use. Provision of safe and portable water must be supported with community education to encourage them to use the safe water to avert cholera outbreak. In some of the communities even though boreholes existed, communities abandoned their use. Sustained community education on the use of safe water would have prevented the cholera outbreak.

The results show that the outbreak affected all the ages (range, 1-84 years) and especially age groups 10 - 19 and 30 - 39. This was consistent with outbreak that occurred in Akim East municipality in November, 2010[12] and 2012 cholera outbreak reported by Ghana. The age group 10 -19 years were older children who may have acquired the cholera through swimming in the river. In cholera endemic communities older age groups are immune to cholera and outbreak tend to affect children under 5 more than the general population. In contrast, the outbreak in Akatsi District, about 7.1% of children under 5 were among the people affected. This was explained by the fact that Akatsi district had not experienced cholera outbreaks for the past six years or more and cholera might not be endemic in the district.

The case fatality rate during the outbreak was 1.2%. This was close to the overall national case fatality rate achieved during the 2012 outbreak (1.0%) comparable to WHO recommendation. This was achieved by opening Cholera Treatment Centre (CTC) close to communities where the cases were coming from. This ensured case were promptly seen and treated. About 40.0% of case-patients delayed more than 24 hours before seeking treatment and this might have contributed to some of the deaths resulting from cholera. In one instance the patient was brought to the health facility dead.

Our findings suggested the outbreak was not food borne. The villages affected were small with population between 400-600 people. Food ate by the people were cooked by themselves or bought. The same river water was used in preparing the food, vibrio cholera bacteria might have been killed during cooking by heat. Drinking raw water from the river without boiling was mainly responsible for the outbreak.

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V. CONCLUSION

The cholera outbreak in Akatsi District was caused by Vibrio cholera serogroup O139 Bengal, isolated from stool and river water samples. The cholera outbreak was water borne as a result of contamination of River Tordzi following rainfall. The communities along the river depended on the river water for domestic use. Even though some of the communities had functional boreholes with safe water they were not used on account of presumed salty taste compared to the river water. The communities have depended on this river for generations before the boreholes were dug for them, to change their attitude to sustain the use of borehole water for domestic activities to protect their health and avert cholera outbreaks in the future, health education in these communities have to be carried out and sustained for a period of time. Some of the communities affected by cholera lack sources of safe water supply and depended solely on River Tordzi. These communities would need boreholes or other sources of safe water for domestic use to avert cholera outbreaks.

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