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ORIGINAL ARTICLE

Cholera outbreak associated with drinking contaminated river water in Panyimur and Parombo sub-counties: Nebbi district, Uganda, March 2017

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Abstract

Introduction: On 10thFebruary 2017, Uganda Ministry of Health was notified of a suspected cholera outbreak in Nebbi district. The district experienced numerous cholera outbreaks with the latest in 2016. We investigated to determine the scope, mode of transmission, and exposures.

Methods: We defined a suspected case as sudden onset of acute watery diarrhoea in a resident (≥5 years) from Parombo or Panyimur sub-counties in Nebbi district, during 1 January-9 March 2017. A confirmed case was a suspected case with culture-confirmed *Vibrio cholerae* from stool. We conducted descriptive epidemiology of case-persons to inform hypothesis generation and a case-control study involving 67 case-persons and 134 control-persons to test the hypothesis.

Results: We identified 222 suspected case-persons; samples from two yielded *Vibrio cholerae* O139. Three case-persons died (CFR=1.4%). The epidemic curve indicated a point-source outbreak. Among 67 cases, 40 (60%) drank river water, compared with 56 (42%) of 134 controls (OR 2.2, 95% CI: 1.2- 4.1). Visual assessment revealed that river water had high turbidity and we observed mass open defecation.

Conclusion: This outbreak affected two sub-counties and was associated with drinking contaminated river water. We recommended treating drinking water by the community members and health education on drinking water safety and proper waste disposal in the communities. And for long term, the district water department should increase the number and functionality of boreholes or piped water in the communities.

Keywords: Cholera, Outbreak, Diarrhoea, Case-control, Uganda.

INTRODUCTION

Cholera continues to be a serious public health problem in several parts of the world, including Uganda [1]. Cholera is an acute bacterial infection caused by ingestion of food or water contaminated with the bacterium *Vibrio cholerae.* There are many serogroups of *V. cholerae* but only two - O1 and O139 - cause outbreaks. Cholera has an incubation period of a few hours to 3 days and commonly presents with acute watery diarrhoea, nausea, and profuse vomiting [2,3]. When untreated, about 50% of cases die due to severe dehydration [2,4]. Infection is most common in areas that lack clean water sources and sanitation services [5]. A cholera outbreak is defined by the occurrence of at least one confirmed case of cholera with evidence of local transmission in an area where there is not usually cholera [3,6].

A cholera rapid diagnostic test (RDT) is available and allows for quick testing of a patient's stool sample. However, the World Health Organization (WHO) suggests that all stool samples testing positive with the RDT are cultured for confirmation. Once an outbreak is confirmed, a clinical diagnosis using WHO standard case definition, accompanied by sporadic testing of cases at regular intervals, is sufficient to count cases [7].

Globally, there are an estimated 1.3 to 4.0 million cholera cases and 21,000 to 143,000 deaths, with 1.3 billion people at risk in cholera-endemic countries [8]. Out of 132,121 cholera cases reported to WHO in 2016 from 38 countries, 71,058 (54%) were from African countries [1]. The risk factors for cholera continue to flourish in many parts of the world with almost 1.8 billion people worldwide drinking water from sources contaminated with faeces, and 2.4 billion people without adequate sanitation facilities [3].

Since 1998, Uganda has been reporting cholera cases and deaths annually [6,9–11]. Cholera is commonly noted before and during the rainy season, from December through March [12]. Cholera outbreaks have been reported from every region, with endemic areas located near rivers or lakes in the western Rift Valley, particularly Lakes Albert, Edward, Katwe, and George [6]. Surveillance data of between 2002 and 2010 in Uganda, showed that about 11,000 cases and 122 deaths occurred each year due to cholera. Most of these cases (81%) occurred in a relatively small number of districts which include areas bordering the Democratic Republic of Congo (DRC), South Sudan, and Kenya as well as the slums of Kampala city [12,13].

Nebbi District, a district bordering the DRC, has experienced numerous cholera outbreaks, which were not investigated, with the most recent in 2015 and 2016. The porous border with the DRC facilitates spread and transmission of communicable diseases. On 10th February 2017, the Uganda Ministry of Health (MoH) received notification of a suspected cholera outbreak in Nebbi District. The District Health Officer (DHO) reported 117 suspected cases with three deaths [case fatality rate (CFR): 2.6%]. A cholera CFR >1% is an indicator of poor management of a cholera outbreak, as stated in the WHO guidelines [3].This particular outbreak was prolonged despite control measures instituted by the district such as health education on boiling and treating of drinking water and encouraging community members to eat hot food and avoid open defecation. To support the district response, we conducted an epidemiological investigation during 5-12 March 2017 to determine the scope and source of the outbreak, and suggest evidence-based control measures to prevent future outbreaks.

MATERIALS AND METHODS

Study area

Nebbi District is located in Northern Uganda, bordered by the Democratic Republic of Congo (DRC) to the west. The district has 15 sub-counties with 93 villages and a total population of about 409,000 [14]. About 8% of the households have access to piped

Supplementary information The online version of this article (Tables/Figures) contains supplementary material, which is available to authorized users.

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water and approximately half use borehole water. The main economic activities are farming and fishing (15).

Case definition

We developed a two-tiered case definition based on the commonest signs and symptoms exhibited by the first cases. We defined a suspected cholera case as sudden onset of acute watery diarrhoea in a resident (≥2 years) from Parombo or Panyimur sub-counties in Nebbi District, from 1 January-9 March 2017. We defined a confirmed case as a suspected case with *Vibrio cholerae* isolated from stool by culture.

Case finding

To identify cases, we reviewed medical records at cholera treatment centres (Parombo Health Centre III and Panyimur Health Centre III) during the outbreak period. We also interviewed case-patients admitted to cholera treatment centres at the time of the investigation and conducted additional case search from the community with the help of Village Health Team members. We developed a line list of cholera case-patients with patient age, sex, residence, date of onset of symptoms, date the patient was seen at a health facility, signs and symptoms, medications administered, laboratory investigations done, and specimens collected. We also interviewed case-patients using a standardized questionnaire about history of: visiting an area that had cholera, going on a trip to the DRC, attending and eating at a social function, or attending a burial of a cholera death. We also assessed sharing of a house with a cholera case, presence and utilisation of a pit latrine, source of drinking water, water treatment methods, types and source of food consumed, and hand washing practices.

Descriptive epidemiology and hypothesis generation

We performed descriptive epidemiology on the line-listed case-patients. We obtained population data from the district population department at both parish and sub-county levels to calculate attack rates. We used an epidemic curve to describe the case-persons by time of onset. Personal characteristics were analysed using Epi Info 7.2.1. We analysed cholera exposures to develop hypotheses that we tested in the subsequent analytic study (case-control study).

Case-control study

In the case-control study, we defined a suspected cholera case as sudden onset of acute watery diarrhoea in a resident (≥5 years old) from Parombo or Panyimur sub-counties in Nebbi District, during 1 January-9 March 2017. A confirmed case-person was a suspected case with *Vibrio cholerae* identified in stool by culture. A control-person was an asymptomatic individual (≥5 years old) from the same village as a case who never experienced diarrhoea during the outbreak period. We identified two village controls for each case-person. If a household had two eligible persons to be controls, we only selected one. Of the 222 suspected case-persons we line listed, we recruited 67 case-persons in the case-control study. These cases were obtained from the three most affected parishes in Parombo and Panyimur sub-counties. If a household had more than two case-persons, we selected the one that had an earlier date of onset. Using the Epi Info 7.2.1 (US Centers for Disease Control and Prevention) statistical option for unmatched case-control studies, we estimated that 134 controls were needed to detect an odds ratio (OR) of 0.52, with a power of 80%, giving a case: control ratio of 1:2. We administered a structured questionnaire to the eligible case- and control-persons to obtain information on their food and water exposures.

Data collection and analysis

We administered a structured questionnaire to the eligible case- and control-persons and asked about demographic variables (i.e age, sex, occupation, place of residence), sources of food (home or restaurant) and drinking water (river, tap or bore hole), water treatment activities (boiling or chlorine treatment), and hygiene and sanitation practices (hand washing with soap and water).

To measure the associations between exposure variables and illness status, we estimated odds ratios (OR) and their 95% confidence intervals. We calculated the proportion of cases and controls who drank untreated river water, who washed hands with soap and water after visiting the toilet, who washed hands with soap and water before eating food, who drank untreated river water, and who drank untreated tap water.

Laboratory investigation

We transported stool samples from two suspected cases in Cary-Blair medium to the Central Public Health Laboratories for confirmation of *V. cholerae* by culture. Three stool samples from subsequent cases were tested using the SD Cholera Ag O1/O139 Rapid Diagnostic Technique (RDT) kit. The RDT was performed following the manufacturer's instructions, using the standard procedure. Approximately 4–6 drops of liquid stool was transferred to a test-tube using a pipette that comes with the dipstick package. The dipstick was then inserted into the liquid stool, and the results were read after approximately 15 minutes. The dipstick had a positive test band and a control band. A test was judged as positive if both the test and control bands appeared. If only the control band appeared, it was judged as negative. If the control band did not appear, the test was judged as invalid[16].

Environmental assessment

We looked for vehicles of transmission using a generated checklist. For sources of drinking water, we mapped out all sources of drinking water and identified water collection points along the rivers that included: Alala River in Parombo sub-county, Nyaloi River in Panyimur sub-county, and the Albert Nile. We visited all water collection points and assessed for evidence of contamination. We subjectively assessed the physical characteristics of the water by looking at transparency/ turbidity, colour, and total suspended solids. We looked at water collection methods, the presence of faeces near the water collection points, and water flow. We also evaluated water collection and storage practices, including storage in open vessels (basins and buckets), and closed vessels (jerrycans). We observed for the presence of human activities at the shores and water collection points. We also visited and observed the defecation field at Dei Village in Panyimur Sub-county (Uganda-DRC border point).

Ethical considerations

The Ministry of Health of Uganda through the office of the Director General Health Services gave the directive and approval to conduct this investigation. Additionally, the office of the Associate Director for Science, Centers for Disease Control and Prevention, Uganda, determined that this investigation was not human subjects' research. We obtained verbal informed consent from case-persons and control-persons above 18 years. For participants below 18 years of age, we sought verbal consent from their parents or guardians. We ensured privacy by conducting interviews in a secure place where none of the people around the home could follow proceedings of the interview. The questionnaires were kept under lock and key to avoid disclosure of personal information of the respondents to members who were not part of the investigation.

RESULTS

Descriptive analysis

The symptoms of the case-persons were consistent with cholera. The commonest symptoms of the case-persons were diarrhoea (100%), vomiting (84%), abdominal pain (48%), and fever (22%) (Table 1).

In total, 222 case-persons were identified by March 2017, including three deaths (case-fatality rate: 1.35%). The median age of case-patients was 17.5 years (range: 6-35 years). Males (attack rate (AR): 13/10,000) were similarly affected as females (AR: 11/10,000). Persons aged $\geq$60 years were the most affected (AR: 57/10,000) followed by persons aged 18-30 years (AR: 32/10,000), 31-59 years (AR: 24/10,000) and <18 years (AR: 23/10,000) (Table 2).

The index case, reported on 1 January 2017, was a 62-year-old male who had travelled from the DRC to visit his relatives in Dei, a border village. The epidemic curve shows a point-source exposure followed by continuous common source exposures. The outbreak lasted for 3 months, from January-March 2017. The highest number of cases (20 case-persons) was reported on 8 February 2017 (Figure 1).

The highest attack rate was in Nyakagei parish (AR 143/10,000) in Panyimur sub-county (Figure 2), which borders the DRC and is separated by Lake Albert and an area called the No-Man's Land.

Case-control study findings

In the case-control investigation, 40 (42%) case-persons and 56 (58%) control-persons drank un-

treated river water (OR: 2.2, 95% CI: 1.2-4.2). None of the other potential exposures investigated were associated with the cholera infection (Table 3).

Laboratory findings

Two stool samples yielded *Vibrio cholerae* O139 by culture. Three other stool samples tested positive for *Vibrio cholerae* by Rapid Diagnostic technique (RDT) test. We did not test all suspected cases due to a limited supply of RDT kits.

Environmental assessment findings

Environmental assessment in Panyimur and Parombo sub-counties showed River Alala, River Nyaloi, and the Albert Nile were the main sources of water for the communities. One of the community boreholes in Nyaloi Village, Nyakagei Parish, Panyimur Sub-county (the most affected sub-county), was locked with a padlock. Further inquiry revealed that a wife of a traditional chief had recently locked this borehole when community members failed to pay a monthly token for maintenance of the borehole. Due to the unavailability of the borehole water, the community members resorted to using water from the nearby Nyaloi River, which was stagnant with high turbidity. The community members use this river as a source of drinking water, water for washing of clothes, kitchen utensils, and bathing. The rivers were not physically protected and the water was turbid. There was open defecation observed in the No-Man's land in Dei Village (Dei Parish, Panyimur Sub-county), bordering the DRC.

DISCUSSION

This was a cholera outbreak that occurred in early 2017 and affected 222 individuals in two sub-counties of Nebbi District, Uganda. Epidemiologic and environmental assessment demonstrated that the outbreak was likely caused by drinking contaminated water from the river, a finding consistent with other cholera outbreaks [17,18].

During the outbreak investigation, we noted that one of the community boreholes in Nyaloi village, Nyakagei parish, Panyimur sub-county – which was the most affected sub-county – was locked with a padlock. This borehole was locked by a wife of a traditional chief as community members failed to pay a monthly token for maintenance of the borehole. Out of respect for her, no one questioned her actions. Because of this, the community members resorted to using water from the nearby Nyaloi River, which was stagnant with high turbidity. The community members were using this river as a source of drinking water, water for washing clothes, kitchen utensils, and bathing. The removal of a safer water option in the form of a borehole in the most-affected sub-county may have contributed to disease spread during this outbreak. Boreholes require maintenance, and the decision to lock this borehole could have been out of necessity; we did not investigate this point. However, it forced community members to find an alternate water source. This underscores the fragility of the safe water access in the area, and demonstrates the ease with which the removal of safer water options can lead to an outbreak.

It is important to note that the most affected sub-counties (Parombo and Panyimur) are border sub-counties to the DRC, and that the border area has very poor sanitation. Bwire et al (2013) noted that most of the places with the highest incidence rates of cholera are either border areas or neighbour countries that have political instability [12]. This closeness to the border poses a risk of cross-border transmission of the disease as persons with cholera can easily cross over from the DRC to Uganda for treatment, trade, or visiting family members and relatives, thus propagating the disease. The first case-person identified in this outbreak was a DRC national who crossed the border to visit his relatives in Uganda. There was an ongoing cholera outbreak in the DRC, so he may have introduced cholera to the outbreak-affected area in Nebbi District, Uganda. On interview, the Nebbi District surveillance focal person noted that previous cholera outbreaks in the district in 2015 and 2016 were likely linked to cross-border transmission; however, these previous outbreaks were not investigated. Cross-border movement at the border of DRC and Uganda has been demonstrated as a contributing factor during previous cholera outbreaks [17,19].

Cross-border transmission calls for stronger cross-border surveillance and collaboration between the Uganda government and the government of the DRC. Thus, surveillance efforts and reporting should be

improved to facilitate better epidemiological characterisation of cholera incidence and improved targeting of interventions to reach those at greatest risk along the border. Cholera is endemic in most border districts including Nebbi since atleast three outbreaks are confirmed within 5 years [12].

Data on cholera surveillance may be combined with the available national reporting statistics to better model cholera burden, which in turn could be used to conduct economic analyses of interventions including use of cholera vaccines in Uganda and consistent provision of safe water [12]. The cholera vaccine has been shown to be effective in reduction of cholera incidences [12,20].

As a result of this outbreak, the Nebbi District Health Office instituted control measures such as community health education and encouraging households to boil all their drinking water. Boiling of drinking water by the community members greatly led to a reduction in the scope of the outbreak.

This investigation had some limitations. It may have been subject to recall bias caused by the differences in the accuracy of the information remembered by the participants over a long period. Recall bias could have led to an over- or under-estimation of the exposures of interest. Another limitation of the investigation is that at the time of the investigation, the National Central Public Health Laboratory did not have testing materials for water. So samples collected where not tested, however, we did a visual assessment of the water sources.

CONCLUSIONS

In summary, our investigation revealed that drinking contaminated river water likely caused this cholera outbreak. We recommended treating drinking water by the community members and health education on drinking water safety and proper waste disposal in the communities. And for long term, the district water department should increase the number and functionality of boreholes or piped water in the communities. The Uganda MoH and DRC MoH should create a joint task force to address poor sanitation in the No Man's land.

INFORMATION

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Authors' contribution. PE took lead in the outbreak investigation, data collection, data analysis, report writing and manuscript writing. SK, IHN, PHA, FLA, MN, DB, JN, CB, DO, DNO, participated in the outbreak investigation, data collection, analysis and manuscript writing under the supervision of BK, ARA. The manuscript was reviewed for intellectual content and scientific integrity under the technical guidance and supervision of BK and ARA. All the co-authors have read and approved the final version of this manuscript.

Competing interest. The authors declare that they have no competing interests.

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Table 1: Distribution of symptoms of 222 cholera case-persons in Nebbi District, Uganda between January and March 2017.

Symptom	Frequency (n)	Percent (%)
Diarrhoea	222	100
Vomiting	186	84
Abdominal pain	107	48
Fever	49	22

Table 2: Distribution of cholera case-persons by age and sex in Nebbi District between January and March 2017.

Characteristic	Frequency(n)	Percent (%)	Population	Attack rates/10,000
Sex				
Female	103	46	42359	11
Male	119	54	41520	13
Age (years)				
<18	111	56.7	47559	23
18 to 30	49	18.4	15434	32
31 to 59	42	20.7	17363	24
60+	20	4.2	3523	57

Table 3: Distribution of risk factors among case and control persons in Nebbi district, Uganda between January and March 2017.

Risk Factors	Cases (n=67)	Controls (n=134)	Cases (%)	Controls (%)	OR	CI (95%)
Drinking contaminated river water	40	56	42	58	2.2	1.2-4.1
Drinking untreated tap water	24	50	32	68	1.0	0.54-1.8
Hand washing with soap before eating	48	82	37	63	1.6	0.85-3.02
Hand washing with soap after visiting the latrine	48	103	32	68	0.8	0.39-1.5

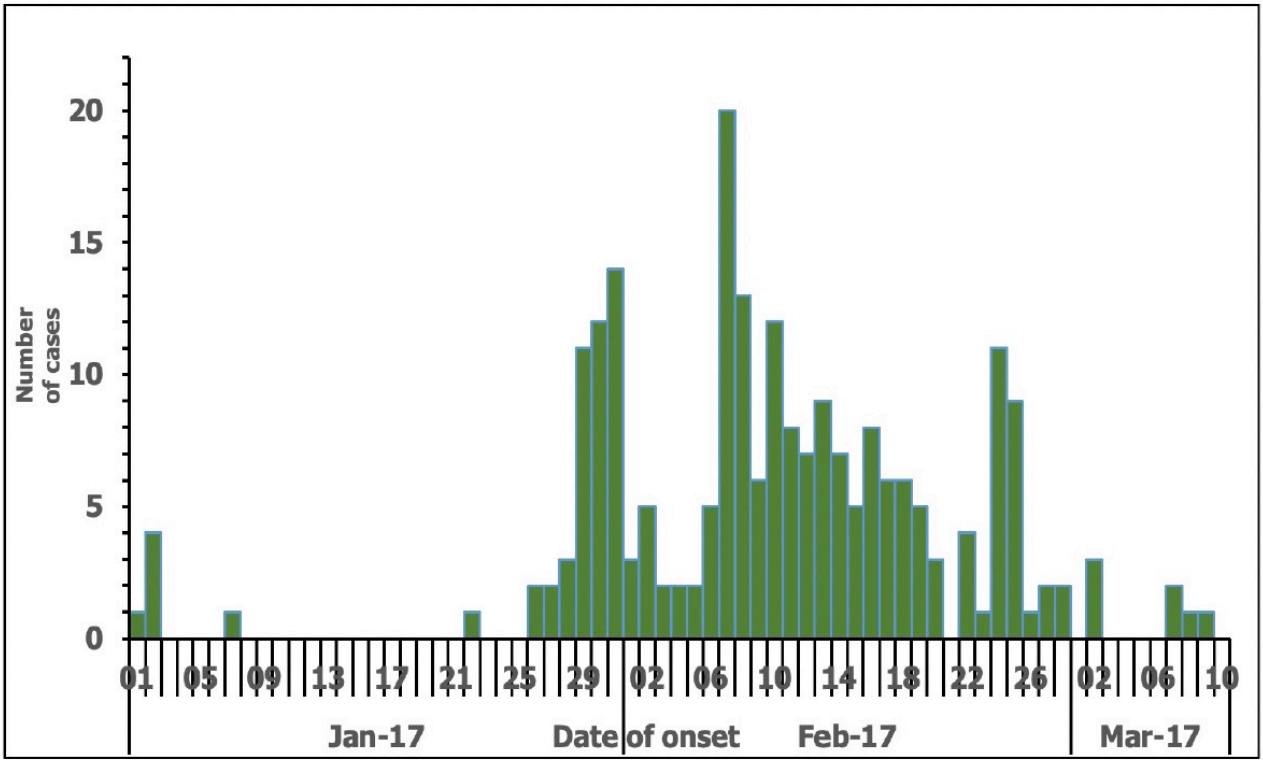

Figure 1: Epidemic curve showing the time of onset of symptoms of case-persons in Nebbi District between January and March 2017

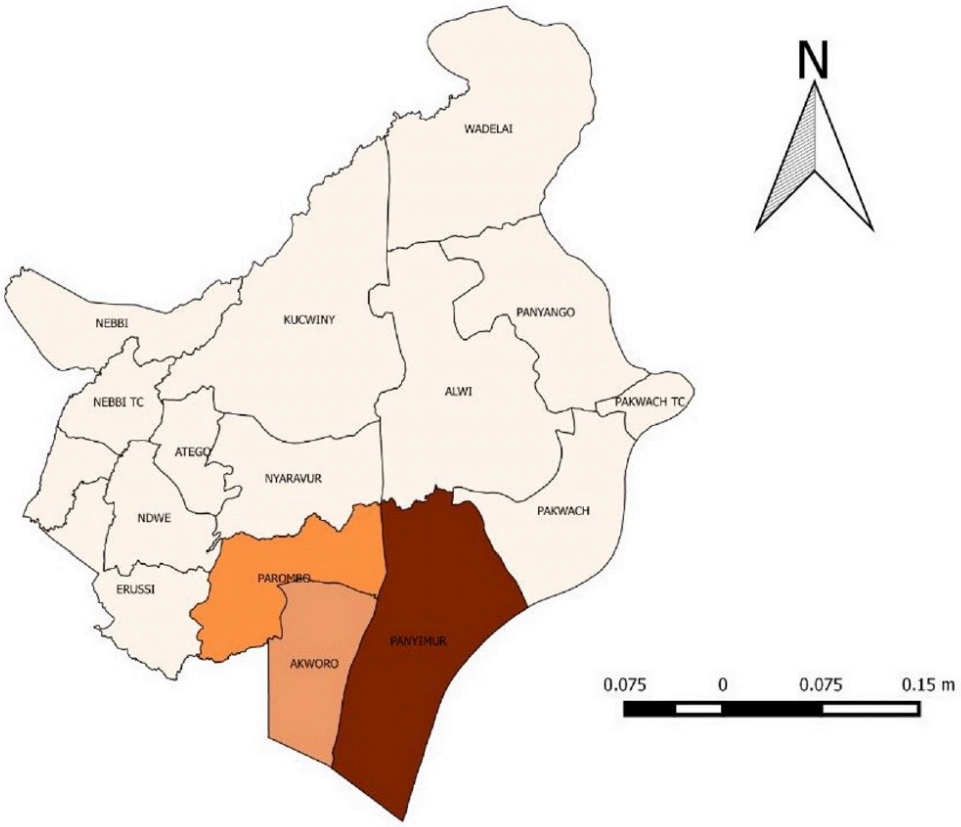

Figure 2: Map of Nebbi District showing the cholera attack rate of case-persons between January and March 2017.