Association between Cholera Outbreak and Traditional Gold Mining in Northern State, Sudan 2017

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Abstract

Introduction: Cholera is one of the health problems causing considerable morbidity and mortality. The Northern State of Sudan experienced a recent cholera outbreak, however, there are limited data on the outbreak. **Methods:** The objective of this study was to assess the magnitude and risk factors associated with the cholera outbreak in the Northern State of Sudan. A retrospective case series study was conducted in the Northern State of Sudan, which involved tracing cases of cholera outbreak of 2017. Data were collected through reports and interviews. A geographical information system was used to map all cases during the outbreak. Chi-square test and logistic regression were used to identify associated factors. **Results:** There were 957 cholera cases reported in the state with an attack rate of 14.2/10,000 persons. Dalgo locality had the highest number (415) of cases reported with an attack rate of 167.2/10,000 persons. About 78% of cases were adult males, while 56.2% of cases were immigrants from other states. Immigrants in Halfa and Dalgo localities were four times (odds ratio [OR] = 4.031, 95% confidence interval [CI]: 2.482–6.547) and eight times (OR = 8.318, 95% CI: 5.674–12.193), respectively, at risk of cholera infection compared to immigrants in Dongola locality. The overall case-fatality rate was 1.9%. This was significantly higher in younger (5.8%) and older (22.7%) age groups ($P < 0.05$). **Conclusions:** The study revealed that the cholera outbreak spread highly along with traditional gold mining areas due to poor sanitation. Therefore, improving sanitation services and establishing an effective surveillance system in these areas are essential to prevent future occurrence of outbreaks.

Keywords: Cholera, Northern State, outbreak, Sudan, traditional gold mining

INTRODUCTION

Cholera is an Acute Watery Diarrhea (AWD) caused by the bacterium *Vibrio cholerae serogroups O1 or O139*.[1-3] It is one of the major health problems in Asia, Latin America, and Africa causing considerable morbidity and mortality.[3-6] The World Health Organization (WHO) is expected that the number of cholera cases continues to rise in developing countries.[7] In 2015, 172,454 cholera cases were reported in 42 countries; 41% of which occurred in Africa, 37% in Asia, and 21% in Hispaniola with 1304 deaths.[2,8] In the same year, South Sudan reported 1818 cases, including 47 deaths (case fatality rate [CFR], 2.6%).[9]

In August 2016, Blue Nile State became the first State in Sudan to report cholera outbreak, the index case came from South Sudan.[8,10] Subsequently, the disease spread to Eastern Sudan, central, and finally to Northern Sudan.[10] According to the Federal Ministry of Health and WHO, 30,762 cases of AWD including 657 related deaths had been reported in the 18 states in Sudan since August 2016.[10] Northern State was affected by this outbreak, and 957 cases were reported in five localities.

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Access this article online

Quick Response Code:

Website:
www.jgid.org

DOI:
10.4103/jgid.jgid_47_20

To provide a scientific basis for the control and prevention of future occurrence of the outbreak, it is important to identify the origin and risk factors associated with a cholera outbreak in the Northern State of Sudan.

METHODS

Study design and population

A retrospective case series study was conducted to investigate the cholera outbreak that occurred between February and September 2017 in the Northern State of Sudan. According to The last census in 2008, the State covers an area of 356,697 km² with a population of 699,605.[11] In 2016, about 15% of the population in the State migrated from other states of Sudan to cultivate tomatoes and to mine gold in Halfa, Dalgo, Al-Burgage, and Dongola localities.[11]

The State is partially a desert with different weather conditions, ranging from hot dry summer to cold winter.[11] It consists of seven localities, namely Halfa, Dalgo, Al-Burgage, Dongola, Al-Goled, Al-Dabba, and Marawi.[11] Sources of drinking water in the state vary as follows: 98% underground, 1.1% River Nile, and 0.9% from valleys and oases distributed in various parts of the desert.[11] In this study, we included all suspected (any person suffering from or dying from AWD) or/and confirmed (any suspected case confirmed by laboratory investigation) cholera cases reported based on the WHO definition for areas with the confirmed outbreak.[12]

Data collection

Data were collected using the archived reports of all cases of cholera collected by the Department of Epidemiology, State's Ministry of Health, and all affected localities. These archived reports provided data involving age, sex, residence, locality, date of onset and admission, symptoms, and outcome of the disease. In addition, key informant interviews were conducted at the local health authorities in the Ministry of Health of Northern State and all affected localities.

Data analysis

Geographical information system was used to identify the spatial distribution of the epidemic by mapping all cases that occurred during the outbreak. Chi-square test was used to determine differences in CFR between different age groups. While the logistic regression analysis was used to determine association between origin of cases with age, sex, and localities; two localities (Al-Burgage and Al-Goled) were excluded in logistic analysis because cases were nonimmigrants. The results were expressed as an odds ratio (OR) and a 95% confidence interval (CI). Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) IBM software version 24.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

During the 7th–36th epidemiological weeks in 2017, a total of 957 cholera cases were reported in the state with 18 deaths accounting for 1.9% CFR. During this period, the state faced

three epidemic peaks in the 7th, 27th, and 32nd weeks; the outbreak first occurred in Dongola locality in the 7th week, spread to Al-Burgage locality in the 12th week, Dalgo locality in the 22nd week, Halfa locality in 23rd week, and the last two cases occurred in Al-Goled locality in the 27th week, as shown in Figure 1.

Figure 2 shows the geographical distribution of cholera cases in the Northern State by localities, in which Dalgo locality had the registered highest number of cases (415) with an attack rate of 167.2/10,000 population, followed by Dongola, Al-Burgage, and Wadi Halfa localities with attack rates of 34.57, 28.47, and 13.34 per 10,000 populations, respectively, as shown in Table 1.

There was an association between CFR and different age groups; younger age group (<15 years) and older age group (>65 years) had the highest CFR 5.8% and 22.7%, respectively, compared to the other age group, as shown in Table 2.

This study shows that more than three-quarter (78%) of cases were males and more than half (56.2%) were immigrants from other states, as shown in Table 3.

Subsequently, through logistic regression, we found that cases who <15 years of age were less likely (OR = 0.281, 95% CI: 0.88–0.897) to be immigrants compared to those who >65 years of age. Those cases who are aged between

Table 1: Distribution of cholera cases among localities in the Northern State 2017

Localities	Population	Number of cases	Cases/10,000
Halfa	35,289	122	34.57
Dalgo	24,824	415	167.2
Al-Burgage	69,892	199	28.47
Dongola	164,105	219	13.34
Al-Goled	67,141	2	0.297
Al-Dabba	140,358	0	0
Marawi	173,872	0	0
Total	675,481	957	14.1678
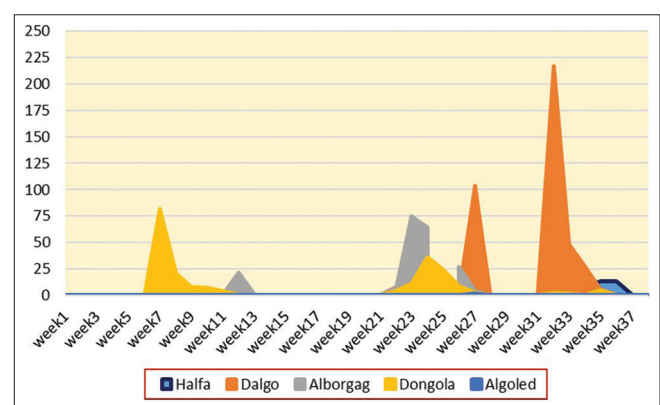
Figure 1: Cholera epidemic curve in the Northern State by locality from February to September 2017
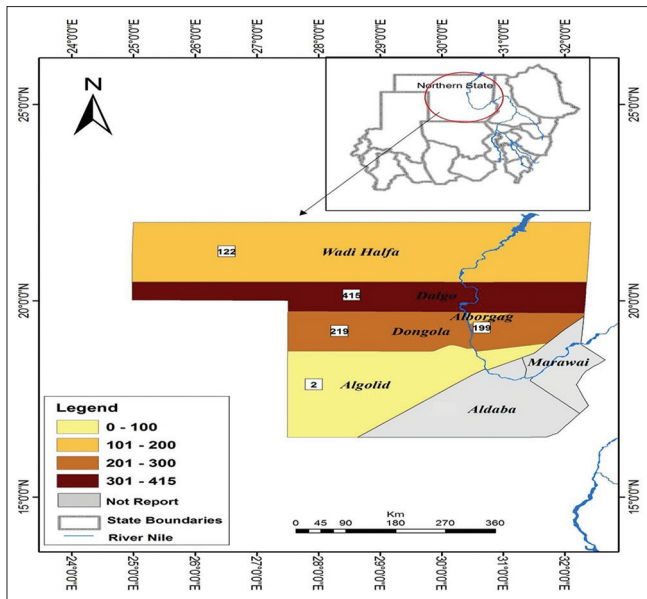
Figure 2: Geographical distribution of cholera cases in the Northern State from February to September 2017

Table 2: Relationship between age group and case fatality rate among cholera cases in Northern State, Sudan 2017

Age group (years)	Outcome		Total, n (%)	P
	Cure, n (%)	Dead, n (%)		
<15	65 (94.2)	4 (5.8)	69 (7.2)	<0.001
15-25	310 (99.4)	2 (0.6)	312 (32.6)	
26-35	282 (98.9)	3 (1.1)	285 (29.8)	
36-45	148 (98.7)	2 (1.3)	150 (15.7)	
46-55	76 (98.7)	1 (1.3)	77 (8.0)	
56-65	41 (97.6)	1 (2.4)	42 (4.4)	
>65	17 (77.3)	5 (22.7)	22 (2.3)	
Total	939 (98.1)	18 (1.9)	957 (100.0)	

15–25, 26–35, and 36–45 years were four and three times more likely to be immigrants (OR = 3.991, 95% CI: 1.580–10.083; OR = 4.153, 95% CI: 1.639–10.526; and OR = 2.959, 95% CI: 1.140–7.682, respectively) compared to those who are >65 years of age. In addition, we found that males were more than 27 times more likely to be immigrants (OR = 27.427, 95% CI: 16.095–46.736) compared to the females. The cholera cases were more than four times likely to be immigrants in Halfa locality (OR = 4.031, 95% CI: 2.482–6.547) and more than eight times likely to be immigrants in Dalgo locality (OR = 8.318, 95% CI: 5.674–12.193) compared to cases in Dongola locality, as shown in Table 3.

Discussion

In 2016, Sudan experienced a nationwide cholera epidemic, the first occurrence in Blue Nile State, confirming that the index cases came from South Sudan.[10] From Blue Nile State, it spread to Eastern, Central, and lastly Northern Sudan.[10] In the Northern State, archived documents revealed the total number of 957 reported cases with an attack rate of 14.2/10,000 persons from February 12 to September 12, 2017. The mean age of cases was 31.41 ± 14.29 years. However, there is a high propensity that this was underestimated since many cases might not have been reported due to limitations in the reporting system and lack of surveillance systems,[13] especially in traditional gold mining areas which had more than half of the cases. Notified cases are often diagnosed in a clinical setting, leading to an increased number of undiagnosed and unreported cases.[14,15] Furthermore, the ratio of asymptomatic-to-symptomatic cases is high ranging from 3 to 100.[7]

The outbreak has been characterized by three peaks varying in size and the spread from one locality to the other, with the largest peak occurring in Dalgo locality in the 32nd week. The first peak in the state started in the 7th week in Algab area which is considered the main traditional gold mining

Table 3: Logistic regression analysis of immigrant's case by age, sex, and locality in Northern State, Sudan 2017

Variable	Total n (%)	Residence, n (%)	Immigration, n (%)	OR (95% CI)	P
Age group (years)					
<15	69 (7.2)	61 (88.4)	8 (11.6)	0.281 (0.88-0.897)	0.032
15-25	312 (32.6)	109 (34.9)	203 (65.1)	3.991 (1.580-10.083)	0.003
26-35	285 (29.8)	97 (34)	188 (66)	4.153 (1.639-10.526)	0.003
36-45	150 (15.7)	63 (42)	87 (58)	2.959 (1.140-7.682)	0.026
46-55	77 (8)	49 (63.6)	28 (36.4)	1.224 (0.446-3.363)	0.694
56-65	42 (4.4)	25 (59.5)	17 (40.5)	1.457 (0.491-4.327)	0.498
>65	22 (2.3)	15 (68.2)	7 (31.8)	Reference	Reference
Sex					
Male	747 (78)	229 (30.7)	518 (69.3)	27.427 (16.095-46.736)	<0.001
Female	210 (22)	190 (90.5)	20 (9.5)	Reference	Reference
Localities					
Halfa	122 (16)	32 (24.6)	90 (75.4)	4.031 (2.482-6.547)	<0.001
Dalgo	415 (55)	61 (8.2)	354 (91.8)	8.318 (5.674-12.193)	<0.001
Dongola	219 (29)	129 (58.9)	90 (41.1)	Reference	Reference

OR: Odd ratio, CI: Confidence interval

area in Dongola locality; the outbreak continued in this area until the 11th week with a total of 123 reported cases. The majority (70.7%) of cases in this locality were immigrants from East Darfur State. This finding indicates that the origin of the outbreak might be from East Darfur State, and then, it moved North to Al-Burgage locality in the 12th week. Subsequently, there were no cases reported during the 13th–21st epidemiological week. The second peak of the outbreak started in the 22nd–27th week in three localities, namely the neighborhood of traditional mining area in Dongola locality, the slum and agriculture populations in Al-Burgage locality, and the traditional gold mining areas in Dalgo locality. While the third peak spread to the Halfa locality in the 23rd week, reported cases continued to emerge from Dalgo locality. Most of the cases in these localities were immigrants from outside of the state working in traditional gold mining areas, characterized by poor environmental management. A study done by Patil *et al.* in 2011 found that migrant workers are more frequently affected by common infectious diseases.[16] The long period of outbreak and its uncontrolled spread to other parts of the state, especially in traditional gold mining areas, reflects poor environmental sanitation and delay of effective interventions which are considered the main reasons for a cholera outbreak.[17] This was further confirmed through the interview outcomes with the local health authorities in the state's ministry of health. They affirmed that the comprehensive interventions took place after the 27th week of the outbreak of cholera.

This study shows that the majority of cases were adult males. This is not in parallel with previous studies carried out in Mexico and Somaliland in which similar distribution of cholera cases was found among males and females.[18] This could be a result of a nongendered context shaping the economic productivity and capability to work in the mine. The overall CFR was 1.9% which is similar to other reports documented by the UNHCR and UNICEF in Sudan cholera outbreak (1.9%) and Somaliland (1.8%) in 2017.[10,18] However, it was higher than the accepted threshold recommended by the WHO ($\leq$1%).[12] This might be due to limited access to proper health-care management and low number of professionals required to initiate a timely response.[19,20]

In this study, we found that younger and older cases reported higher CFR compared to other age groups ($P < 0.05$). This may be due to the physiological differences among these age groups. They are biologically characterized to have a decreased amount of hydrochloric acid due to low gastric secretions. Hence, they usually have high gastric pH with a high propensity to increase the severity of cholera disease.[21]

Overall, these findings strongly suggest that cholera outbreak spread along with traditional gold mining areas in the state due to poor environmental sanitation in which the spread of cholera was exacerbated by poor water supply, hygiene, and sanitation (WASH).[22-25] In addition, the absence of an effective surveillance system and timely intervention might

have contributed to the unbridled nature of the spread of the cholera outbreak.

There are some limitations to our study. First, the study relied on secondary data, which may lack some relevant information (e.g., risk factors) needed to further explore the characteristics of the outbreak. Second, poor reporting system and the absence of effective surveillance system might have limited underestimated the available data obtained from the archived data.

CONCLUSIONS

This is the first reported cholera outbreak in the Northern State, Sudan. Most cases are adult males and immigrants from other states of Sudan, mainly concentrated around gold mine areas in Dalgo and Halfa localities. In addition, CFR is high among younger and elder age groups compared to other age groups. The cholera outbreak could have been due to poor water supply, low level of hygiene, and poor sanitation in the gold mine areas. The outbreak was also exacerbated by the absence of an effective surveillance system required for timely intervention. Therefore, it is essential for government to provide pipe-borne water and other facilities that will maintain high-level sanitation, especially in traditional gold mining areas to prevent future outbreaks. In addition, there is an urgent need to establish an effective cholera and other infectious disease surveillance system for future timely intervention.

Research quality and ethics statement

This study was approved by the Institutional Review Board / Ethics Committee in the Ministry of Health, Northern State, Sudan. IRB No 8R-25/1/018 . The authors followed applicable EQUATOR Network ("http:// www.equator-network.org/) guidelines during the conduct of this research project.

Conflicts of interest

There are no conflicts of interest.

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