

Countrywide Outbreak of Acute Watery Diarrhea in Sudan, 2016 - 2018

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Abstract

Background: During the period between August 2016 and May 2018, Sudan experienced an outbreak of Acute Watery Diarrhea (AWD) that spread to all of the 18 States of the country; and required a multi-sectoral response to end it. The main objective of this report is to describe the epidemiological characteristics of the prolonged outbreak.

Methods: The investigators compiled and analyzed national and State epidemiological disease surveillance data, drew a series of epidemic curves and maps, calculated Attack Rates (AR) per 10,000, and computed Case-Fatality-Ratio (CFR) stratified by State. Focus Group Discussions (FGD) were used to understand factors that contributed to the spread of the outbreak.

Results: The national disease surveillance system reported 36,962 cases of AWD from all 18 States. The mean age \pm Standard Deviation (SD) and Inter-Quartile Range (IQR) of AWD cases were 32.0 ± 21.1 (15 – 45). The crude AR was 9.2 per 10,000 population but varied among States (range: 2.4 to 33.5). The AR increased with age from 5.1 among children under 5 years of age to 241 in population aged 60 years or older, and was consistently higher among females across age groups. Of all cases, 823 deaths occurred (Crude CFR = 2.2%). All States experienced 2 or 3 waves of the outbreak that lasted on average for 5 to 6 weeks except White Nile State, which had a single 30-week long wave. More cases of AWD occurred in areas inhabited by Internally Displaced Population (IDP), Quranic schools (Khalwas), prisons and traditional gold miners. The investigation team observed rampant open defecation practice in most of the affected areas. The FGDs revealed that some communities were resistant to using chlorinated water due to erroneous beliefs and misconceptions.

Discussion: The prolonged and widespread AWD outbreak and the associated high CFR underscores the need to advocate the importance of having a preparedness plan, sharing timely information, improved case management and instituting other effective control measures. With rampant Open Defecation and widespread misconception on use of chlorinated water, the likelihood of having a new outbreak remains inevitable.

Keywords: Acute Watery Diarrhea (AWD); Outbreak, Attack Rates (AR); Case-Fatality Rates (CFR); Sudan

Introduction

Acute Watery Diarrhea (AWD) is defined as, ‘any patient presenting 3 or more liquid stools with or without vomiting for the last 24 hours’ [1]. The Sudan has experienced repeated outbreaks of AWD during the last five decades. During the period between 1966 and 2014, the country witnessed 15 major outbreaks of AWD. The past AWD outbreaks were mostly of limited spread affecting one to three States except for 2006, 2011 and 2014 when the AWD outbreaks affected all of the 18 States of the country (Table 1). During the period between May-August 2016, four out of seven countries bordering Sudan reported outbreaks of AWD or Cholera [2-7].

Year	State Affected
1966	Gadaref
1970	Gadaref
1972	Equatoria (Juba) and All Northern States (n = 15)
1978	No data available
1980	South Darfur
1981	Gadaref
1988	Khartoum, Northern State and Red Sea
1999	Khartoum, Gadaref, North Kordofan, Red Sea and Kassala
2002	North Kordofan
2000-2004	All Darfur States
2006	All States*
2007	Kassala, Gadaref and Sennar
2008	Gadaref
2010	All States*
2014	All States

Table 1: Previous AWD outbreaks in Sudan.

*: There were only 25 Administrative States in Sudan in 2006 that include the 10 States of South Sudan.

On 17 August 2016, the Federal Ministry of Health (FMOH), Sudan identified a case of AWD in Kassala State of eastern Sudan. There was a concurrent report of AWD cases from Blue Nile State, southeastern Sudan. Subsequently, the disease surveillance system, FMOH, detected more cases of AWD from different States. The outbreak continued and spread all over the country. When the outbreak reached its peak, about one year after the emergence of the outbreak, the government established an Inter-Ministerial Committee to coordinate the activities of different ministries involved in the control measures, and mobilized resources. In May 2018, the FMOH declared that Sudan is free from cases of AWD [8]. The main objective of this study is to describe the epidemiological characteristics of the prolonged AWD outbreak that occurred in 2016-2018.

Materials and Methods

The Sudan is located at northeastern Africa bordering seven countries and the Red Sea; namely, Egypt, Libya, Chad, Central African Republic, South Sudan, Ethiopia, and Eritrea. The borders with neighboring countries are long and porous. The estimated population of Sudan in 2017 is 40.2 million [9]. Administratively, the Sudan is divided into 18 States with 187 localities. The civil unrest in neighboring countries coerced large numbers of people to seek refuge in the Sudan; especially from South Sudan, Eritrea and Ethiopia.

During the International Week (IW) 23 of 2017, the government established an Inter-ministerial Committees that led to intensified control measures thereafter. The investigators compiled and analyzed available national and State epidemiological disease surveillance data, and situation updates. The investigators calculated State-, age-, and sex specific Attack Rates (AR), and Case-Fatality Ratio (CFR). Standard case definition for AWD is used to calculate AR and CFR. AR is calculated as proportion of cases among at risk population per 10,000 population. The total population in the affected localities were used as denominator, population at risk of AWD, in calculating AR. CFR is calculated as percentage of deaths among AWD cases. The investigators held a series of Focus Group Discussions (FGD) in the field with community members to understand factors contributed to the spread of the outbreak. We asked probing questions to explore barriers to use chlorinated water and hygiene and sanitation practices. Further details of the field activities were published elsewhere [10-12].

Results

Attack Rates (AR) and Case Fatality Rates (CFR)

The outbreak of AWD started on 17 Aug 2016 (International Week (IW) 29 of 2016) in Kassala State and spread to all of the 18 States of the country. The outbreak continued for 21 months and ended on 06 May 2018 (IW 8 of 2018). Figures 1 shows the epidemic curves of the AWD outbreak in the most affected States and its spread across the country.

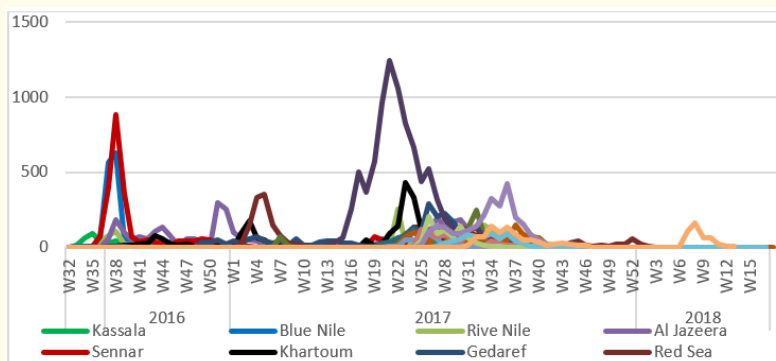


Figure 1a: Epidemic curve of Acute Watery Diarrhoea (AWD) outbreak in 8 selected States of Sudan, wk33/2016-wk17/2018.

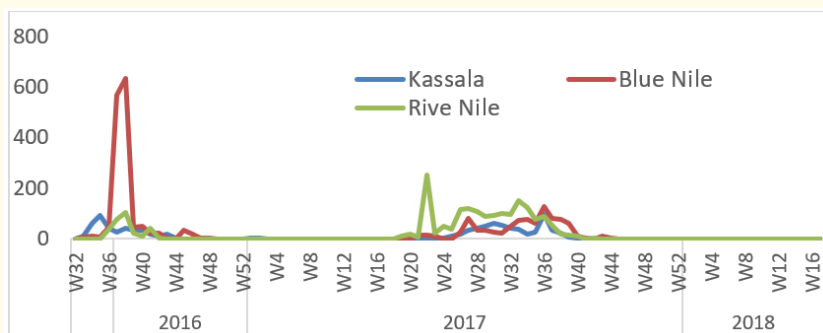


Figure 1b: Epidemic curve of Acute Watery Diarrhoea (AWD) cases, Sudan, 2016-2018.

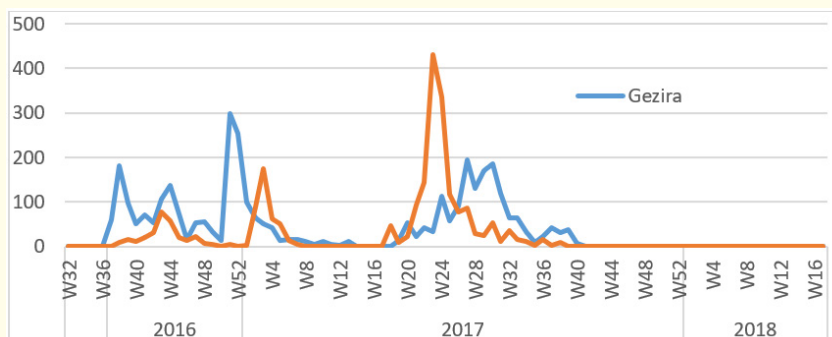


Figure 1c: Epidemic curve of Acute Watery Diarrhoea (AWD) outbreak in Gezira and Khartoum, IW 33 of 2016 - IW 17 of 2018.

The national disease surveillance system reported 36,962 cases of AWD from all States during the outbreak period. The overall AR of the outbreak was 9.2 per 10,000 population. Table 2 and figure 2 summarize the variation in AR among different States. The highest AR per 10,000 population occurred in White Nile (33.5), Blue Nile (20.5), Northern (20.0) and Sennar (18.9) States; whereas, the lowest AR occurred in West Kordofan (2.4) and Khartoum (3.3) States. The AR were consistently higher among females than males (Table 2) except for Khartoum, Red Sea and Northern States. The AR per 10,000 population increased with age from 5.1 among children under 5 years of age to 241 in population aged 60 years of age or older. The AR was consistently higher among females at all age groups (Table 3).

State	Male					Female					Total				
	Population	N	D	AR	CFR	Population	N	D	AR	CFR	Population	N	D	AR	CFR
Kassala	934,169	472	18	5.1	3.81	919,341	486	5	5.3	1.03	1,853,509	958	23	5.2	2.4
Blue Nile	580,778	965	34	16.6	3.52	571,560	1393	44	24.4	3.16	1,152,338	2358	78	20.5	3.31
Rive Nile	705,942	967	13	13.7	1.34	694,736	986	17	14.2	1.72	1,400,678	1953	30	13.9	1.54
Gezira	2,513,403	1694	35	6.7	2.07	2,473,508	1740	31	7	1.78	4,986,911	3434	66	6.9	1.92
Sinner	999,844	1743	14	17.4	0.8	983,973	2001	20	20.3	1	1,983,817	3744	34	18.9	0.91
Khartoum	3,479,605	1344	23	3.9	1.71	3,424,373	911	10	2.7	1.1	6,903,978	2255	33	3.3	1.46
Gadaref	1,188,190	1066	13	9	1.22	1,169,330	1200	20	10.3	1.67	2,357,520	2266	33	9.6	1.46
Red Sea	549,604	851	11	15.5	1.29	540,880	733	10	13.6	1.36	1,090,484	1584	21	14.5	1.33
Northern	226,543	683	10	30.1	1.46	222,947	216	7	9.7	3.24	449,490	899	17	20	1.89
White Nile	1,328,005	3517	51	26.5	1.45	1,306,926	5307	61	40.6	1.15	2,634,931	8824	112	33.5	1.27
North Kordofan	999,844	539	7	5.4	1.3	983,973	575	6	5.8	1.04	1,983,817	1114	13	5.6	1.17
South Kordofan	831,271	512	36	6.2	7.03	818,076	709	49	8.7	6.91	1,649,347	1221	85	7.4	6.96
West Kordofan	730,546	150	22	2.1	14.67	718,950	193	11	2.7	5.7	1,449,496	343	33	2.4	9.62
North Darfur	841,459	238	10	2.8	4.2	828,102	436	19	5.3	4.36	1,669,561	674	29	4	4.3
East Darfur	383,675	368	21	9.6	5.71	377,585	407	22	10.8	5.41	761,260	775	43	10.2	5.55
South Darfur	2,847,968	1089	42	3.8	3.86	2,802,762	1479	81	5.3	5.48	5,650,730	2568	123	4.5	4.79
West Darfur	613,461	252	13	4.1	5.16	603,723	432	6	7.2	1.39	1,217,184	684	19	5.6	2.78
Central Darfur	524,076	549	14	10.5	2.55	515,756	759	16	14.7	2.11	1,039,832	1308	30	12.6	2.29
Total	20,278,381	16999	387	8.4	2.28	19,956,501	19963	435	10	2.18	40,234,882	36962	822	9.2	2.22

Table 2: Distribution of cases of Acute Watery Diarrhea (AWD), Attack rates (AR) per and case Fatality Rates (CFR) percent in different states of Sudan during an outbreak of AWD, 2016 - 2018.

Age Group	Male					Female					Total				
	Pop	N	D	AR	CFR	Population	N	D	AR	CFR	Population	N	D	AR	CFR
Less than 5	3,027,175	1,667	44	5.5	2.64	2,924,994	1,385	39	4.7	2.82	5,952,169	3,052	83	5.1	2.72
5 - 9.9	2,746,327	1,662	43	6.1	2.59	2,663,191	1,369	27	5.1	1.97	5,409,518	3,031	70	5.6	2.31
10 - 19.9	4,680,001	2,936	43	6.3	1.46	4,559,696	2,861	37	6.3	1.29	9,239,697	5,797	80	6.3	1.38
20 - 29.9	3,447,655	2,907	30	8.4	1.03	3,392,580	3,815	49	11.2	1.28	6,840,235	6,722	79	9.8	1.18
30 - 39.9	2,534,931	2,223	47	8.8	2.11	2,530,218	3,454	57	13.7	1.65	5,065,149	5,677	104	11.2	1.83
40 - 49.9	1,716,138	1,664	47	9.7	2.82	1,756,200	2,533	58	14.4	2.29	3,472,338	4,197	105	12.1	2.5
50 - 59.9	1,059,251	1,335	33	12.6	2.47	1,115,766	1,607	27	14.4	1.68	2,175,017	2,942	60	13.5	2.04
60 - 69	621,574	2,605	100	41.9	3.84	670,894	2,939	141	43.8	4.8	1,292,468	5,544	241	42.9	4.35
70+	365,155	16,999	387	465.5	2.28	423,136	19,963	435	471.8	2.18	788,291	36,962	822	468.9	2.22
Total	20,198,207	33,998	774	16.8	2.28	20,036,675	39,926	870	19.9	2.18	40,234,882	73,924	1644	18.4	2.22

Table 3: Distribution of cases of age-sex distribution of Attack Rates (AR) per 10,000 and Case Fatality Rates (CFR) percent during an outbreak of Acute Watery Diarrhea (AWD), Sudan 2016-2018.

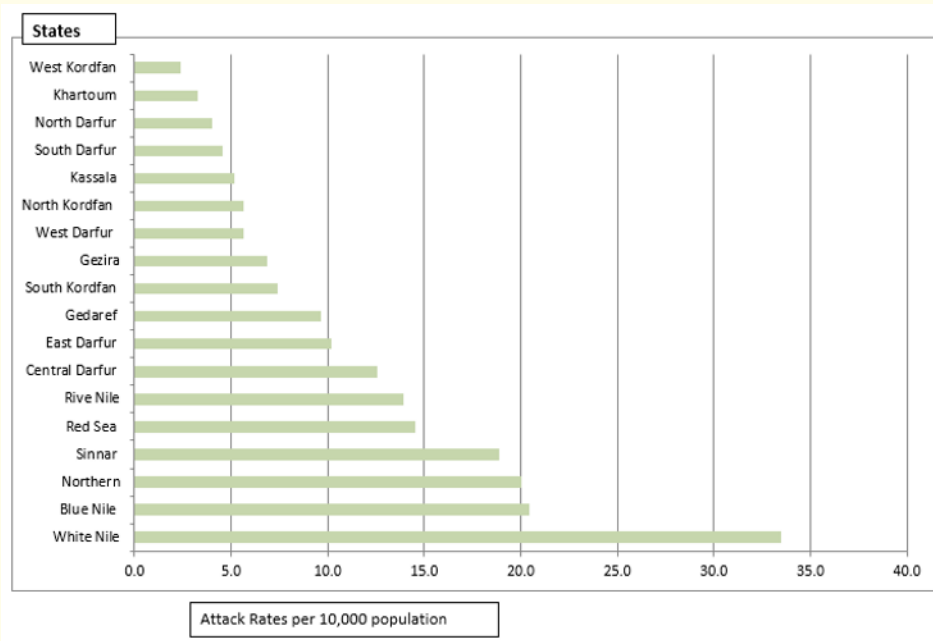


Figure 2: Attack Rate (AR) per 10,000 populations of Acute Watery Diarrhea (AWD) by State, Sudan, 2016 - 2018.

Of all cases, 823 deaths occurred (Crude Case-Fatality Rate percent [CFR] = 2.2%). The CFR varied among States; ranged from less than 1% (0.91%) in Sennar to as high as 9.6% in West Kordfan. Half of the States had more than CFR of 2% and the rest had CFR of less than 2%. Six States had CFR more than 3.31% (Table 2 and Figure 3). The mean age in years and the Standard Deviation (\pm SD) of AWD cases was 32.0 ± 21.1 ; the Inter-Quartile Range (IQR) was 15 - 45 years. Table 4 shows the age distribution of cases in different States. Table 5 summarizes the univariate analysis of the age distribution of deceased and survived cases. The difference between the mean age \pm SD of survivors (31.8 ± 20.1) and the deceased (36.9 ± 25.2) was statistically significant ($P < 0.0001$), *t*-test, difference between two means.

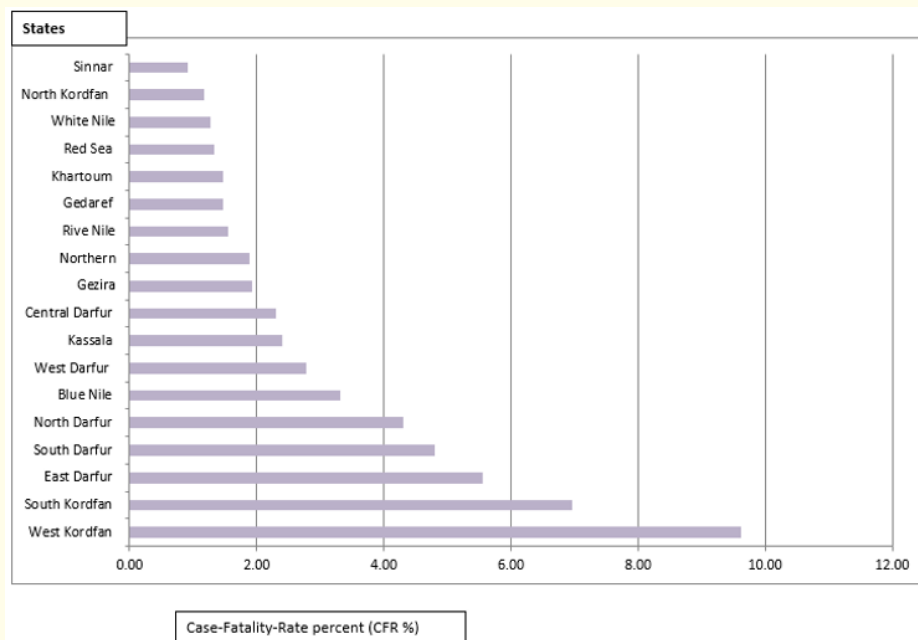


Figure 2: Attack Rate (AR) per 10,000 populations of Acute Watery Diarrhea (AWD) by State, Sudan, 2016 - 2018.

	N	Mean	SD	Median	Mode	Minimum	Maximum	Inter-Quartile Range
Sudan	36,962	32	21.1	29	35	0.1	112	15 - 45
White Nile	8,824	29.3	21	25	35	0.1	110	12 - 42
Sinnar	3,744	34.5	20.2	32	30	0.17	95	19 - 50
Gezira	3,434	36.3	20.9	34	50	0.11	95	21- 50
South Darfur	2,568	33.9	23	30	35	0.5	112	14 - 50
Blue Nile	2,358	31.9	21.1	28	35	0.25	95	15 - 45
Gadaref	2,266	35.6	19.7	34	35	0.83	95	20 - 50
Khartoum	2,255	32	18.8	28	25	0.58	93	18 - 45
Rive Nile	1,953	30.7	21.5	27	35	0.33	95	14 - 45
Red Sea	1,584	23.8	21.1	17	2	0.9	90	15 -40
Central Darfur	1,308	30.3	21.7	28	35	0.48	100	16.7-42
South Kordofan	1,221	33.1	20.8	30	35	0.4	100	16 - 46
North Kordofan	1,114	33	22.6	30	70	0.5	90	14 - 50
Kassala	958	33	20.6	30	30	0.5	85	15 - 49
Northern	899	31	14.3	28	25	0.92	82	22 - 39
East Darfur	775	29.8	21.8	27	35	1	90	10 - 45
West Darfur	684	37.4	22.9	35	35	0.25	97	19 - 59
North Darfur	674	34.5	21.4	30	30	0.5	110	18 - 50
West Kordofan	343	25.9	22.1	18	8	0.5	85	8 - 40

Table 4: Age distribution of Acute Watery Diarrhea (AWD) cases by different states of Sudan during an outbreak of AWD, 2016-2018

Survivors									
	N	Mean	SD	Mean	Median	Mode	min	Max	IQR (Q1 - Q3)
Male	16612	30.78	21.93	30.78	26	35	0.1	112	Dec-45
Female	19527	32.72	20.1	32.72	30	35	0.1	108	18 - 45
Total	36139	31.83	20.99	31.83	29	35	0.1	112	15 - 45
Difference between the mean age of male and female cases was statistically significant (t-test, p < 0.0001)									
Deceased patients									
Male	387	36.8	26.04	36.8	36	70	0.2	110	Nov-60
Female	436	40.67	24.36	40.67	40	70	0.1	90	21- 64
Total	823	38.86	25.22	38.86	38.5	70	0.1	110	16 - 60
Difference between the mean age of male and female cases was statistically significant (t-test, p < 0.0001)									
All cases									
Male	16612	30.78	21.93	30.78	26	35	0.1	112	Dec-45
Females	19527	32.72	20.1	32.72	30	35	0.1	108	18 - 45
Total	36139	31.83	20.99	31.83	29	35	0.1	112	15 - 45

Table 5: Age distribution of surviving and deceased cases of Acute Watery Diarrhea (AWD) during an outbreak of AWD, 2016 - 2018.

The beginning and spread of the outbreak

The first suspected case of AWD was reported from *Hamadite* town in *Wad Al Helew* locality in Kassala State to the State Ministry of Health (SMOH), which notified the FMOH within 48 hours. The index case was a middle-aged Sudanese who presented with history of one day of vomiting and rice watery diarrhea. On the 18 Aug 2016, another case of AWD was reported from the same town. A few days later, a cluster of AWD cases occurred around the market place in *Hamadite* town. The newly detected cluster of cases confined to a group of motels occupied by hundreds of expatriate seasonal workers from Ethiopia. The workers were awaiting their relocation to a nearby farm. On 20 Aug 2016, the SMOH deployed a joint FMOH/SMOH team, which decided to temporarily close some motels and restaurants for about a week because the sanitary conditions in the motels were deplorable. After 10 days, the disease surveillance system detected more cases of AWD in another locality and subsequently in other nine neighboring localities. The outbreak continued in Kassala State for 11 weeks, from IW 33 to IW 44 of 2016.

Cases of AWD were also reported from Blue Nile State during the same IW when cases were reported from Kassala State (i.e. IW 33 of 2016). On 36 IW of 2016, three weeks after emergence of AWD cases in Kassala and Blue Nile States, cases of AWD started to appear in River Nile State. By 35 IW of 2016, the outbreak of AWD spread to four States. By IW 38 of 2016, seven States were affected. By IW 26 of 2017, the outbreak reached 16 States, and all 18 States by IW 31 of 2017. The series of maps on figure 4 shows the spread of AWD across different States during the outbreaks. The last wave of the AWD outbreak reported from Central Darfur State. The epidemic curves (Figure 1a-1c) showed that each State had two or three waves of the outbreak that lasted on average for five to six weeks except for White Nile State. There was a single wave of the AWD outbreak in the White Nile State, which continued for 30 weeks (IW 13 to IW 43 of 2017). On 06 May 2018, the FMOH declared that the country is free of AWD after lapse of 4 weeks of zero cases reported from any of the 18 States. During the outbreak, the AWD taskforce held regular meetings; yet, the Emergency Operation Centre (EOC) was not utilized.

Map 7	Map6	Map 5	Map 4	Map 3	Map 2	Map1	
500- 1000	1- 50	100- 200	10-50	0 - 10	1- 50		
1001- 1500	21 - 100	201- 600	51- 200	10- 50	51 - 200	1 - 50	
1501- 2500	100 - 190	601- 800	201- 500	50 - 100	201- 300	51 - 250	
2501- 5000	190- 319	801- 1200	502 - 1000	100 - 500	301- 501	250 - 500	
5001- 10000	319 - 501	1201- 2000	1001 - 5000	500 -1000	501 - 1000	500 -2000	

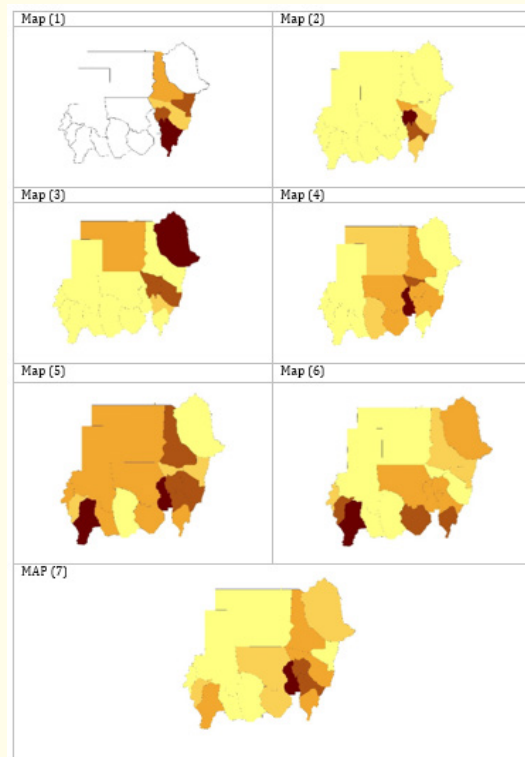


Figure 4: Administrative map of Sudan showing the country-wide spread of the outbreak of acute watery Diarrhoea (AWD) during the period between International Week (IW) 29 of 2016 to IW 8 of 2018. Each map summarizes the outbreak of a 12-week interval. It should be noted that the maps shows the relative frequency of cases between different States as the legend that stratifies the number of cases vary from one map to another.

Potential risk factors

More cases of AWD were reported from areas inhabited by Internally Displaced Population (IDP), Quranic schools (*Khalwas*), prisons and traditional gold miners in River Nile State. The investigation team observed rampant open defecation practice in most of the affected areas.

During the outbreak, the SMOH implemented zero reporting of AWD cases. The RRT mapped and chlorinated water sources, provided water reservoirs, and monitored water quality for Free Residual Chlorine (FRC) and coliform count. The FGD with community revealed that the villagers preferred to drink unchlorinated water directly from the river. Villagers along the bank of the White Nile river stated that the chlorination of water did not only make the odor of water unacceptable for drinking or domestic use and good for ablution for their prayers, but also causes infertility.

The interviews with senior officials at federal and State levels revealed that there was a preparedness plan for rainy season, where the States received some medical supplies. The preparedness plan was not fully funded. At the State level, there was high turnover of Rapid Response Team (RRT); the attrition among the RRT members was as high as 40% in many States. The senior officials at the State level admitted that they used the pre-positioned emergency stockpiles of medical supplies for treatment of regular patients during non-outbreak periods. An AWD-specific preparedness and response plan was developed during the outbreak.

The health authorities at the State level distributed printed health education materials that contained more than 40 messages; not audience specific. There was inadequate use of social media (e.g. WhatsApp, Facebook, Instagram etc.). On Fridays, religious leaders (*Imams* of mosques) advised the public on AWD prevention and control; and addressed unfounded rumors and misbelief about use of chlorinated water. Other ways of communication that were used during the outbreak included mass media (radio and television), public sound systems (mobile vans and trucks), mosques, and street drama to “broadcast” messages in villages and localities.

Discussion

The AWD outbreak was unusual; it continued for a long period, had wider geographical distribution and was associated with a relatively high CFR.

Case fatality rate

The study showed that the crude CFR was high (2.22%) according to WHO guidelines; with proper treatment, the CFR of AWD outbreaks should remain below 1% [13]. The CFR in this study was relatively higher among older patients and varied among States. Half of the States reported CFR more than 2% while one-third reported more than 3.31%. The CFR during the outbreak could probably be higher than reported because the data was limited to sentinel health facilities. The statistical difference in the mean age in years between the deceased and the survivors (31.8 vs 36.9) could be attributed to the large number of cases and or rounding effect of age reporting of patients. The CFR during this outbreak was much higher than a comparable countrywide prolonged outbreak that occurred in Yemen (CFR = 0.22%), although the health services in Yemen were disrupted because of an on-going civil war during the outbreak [14].

High CFR reflects limited access to proper health care for the most vulnerable people and insufficiencies in health-care systems, including limited capacity of the surveillance system to trigger timely responses [12]. The variation in CFR due to AWD among States in Sudan clearly reflects the difference in response capacities, mainly in the quality of management of AWD cases. The high CFR during this outbreak could be due to inadequate training of the RRTs at the State level and not activating the Emergency Operation Centre (EOC) to monitor the outcome of control activities. The wide range of CFR among districts in Kenya (CFR 0 - 14%) was related to healthcare access disparities, including availability of rehydration supplies [15].

Chlorination of water

Chlorine safeguards against microbial contamination in water, including cholera [16]. People in different States varied in their access to chlorinated drinking water during the outbreak [17]. It is conceivable that some people resented using chlorinated water because of the

changes in taste and odor. Likewise, the change in the taste and smell of chlorine and local beliefs in Guatemala influenced consumption of chlorinated water [18]. Moreover, this study revealed that there was widespread circulation of other misconceptions about use of chlorinated water in many parts of Sudan. The delay in accepting the chlorinated water could have contributed to the prolongation of the outbreak, having more than one wave of the outbreak and increased the AR in many States.

The FMOH lacked a communication strategy tailored to address local erroneous beliefs related to chlorinated water. During the outbreak, the health education messages conveyed to the public were too many and were neither audience nor context specific. The FMOH needs to develop pilot-tested and context-specific messages that address misconception on use of chlorinated water. The FMOH needs to monitor effectiveness of the communication interventions as measures by change in behavior and practice of the public through repeated Knowledge Attitude and Practice (KAP) surveys.

Open defecation practices

The results of this study indicated that some rural communities do not view lack of a toilet or Open Defecation (OD) practice as unacceptable. Only one-third of the population in Sudan have access to improved sanitation facilities; and about 29% of the population have no access to sanitation facilities at all and continue to defecate in the open [17,19]. Poor access to sanitation most probably contributed to the spread of the outbreak in Sudan. Addressing the issue of OD was the weakest intervention during the outbreak [17]. Some communities were aware of the health risks related to poor sanitation, specifically of not using toilets, but they continued with unhealthy practices due to lack of access to latrines. As OD was found to be rampant among under-served populations (e.g. gold miners, migrant workers and nomads), there is a dire need for innovative and targeted strategies to combat OD practice in those places.

Preparedness plan

During the outbreak, it was clear that there was inadequately funded preparedness and response plan and misuse of prepositioned medical emergency supplies. The States consumed the meagre prepositioned stockpiles of supplies before the outbreak without replenishment. Such practice defeated the purpose of stockpiling. It is most likely that States could not fully comprehend the rationale for prepositioning medical supplies as part of the preparedness plan. The purpose of development of preparedness plans are three-fold: to prevent, or delay occurrences and reduce morbidity and related mortality during public health emergencies. Preparedness should be regarded as a continuous process of developing, updating, testing and monitoring operational plans and strategically placing adequate emergency supplies.

Many countries ingrained emergency preparedness plans into their health systems as part of national health security. The concept of preparedness and building competent national core capacities to early detect and timely respond to public health emergencies has been clearly emphasized by the International Health Regulation (IHR) [20]. During the outbreak, the efforts of putting in place the RRT mechanism at national and State levels, as part of the national preparedness plan, was less rewarding than expected due to the high turnover and attrition of trained RRTs in Sudan.

Conclusion

The long duration and the associated high CFR of the outbreak could have been significantly reduced by having a fully funded preparedness plan, timely sharing of epidemiologic information with relevant partners and monitoring of CFR. With rampant OD and widespread misconception on use of chlorinated water, the recurrence of outbreaks of AWD and other water and sanitation-related disease is inevitable.

Declarations

Ethics approval and consent to participate. Not required because there is no human subject involved.

Consent to Publish

Not applicable.

Availability of Data and Materials

Authors used surveillance and published data. References cited.

Competing Interests

None.

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Authors' Contributions

Dr N. Al-Gasser and Dr A. Yeneabat prepared the tools used for the study. All authors participated in field visits, interviews, review of surveillance data, and discussions, interpreting observations. Dr H. El Bushra and Ms. M Alzain conducted the statistical analyses; Dr H El Bushra prepared the manuscript from the evaluation team report. All authors reviewed and discussed the manuscript.

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Bibliography

1. Federal Ministry of Health (FMOH). "Sudan National AWD Preparedness and Response Plan, March 2018" (2018).
2. World Health Organization (WHO). "Ethiopia Country Office. Emergency Response, Situation Report 22-27 May 2016" (2016).
3. World Health Organization (WHO). "South Sudan health situation reports" (2019).
4. World Health Organization (WHO). "Regional Office for Africa. South Sudan declares the end of its longest cholera outbreak" (2019).
5. Nsubuga F, *et al.* "Epidemiological description of a protracted cholera outbreak in Tonj East and Tonj North counties, former Warrap State, South Sudan, May-Oct 2017". *BMC Infectious Diseases* 19.1 (2019): 4.
6. World Health Organization (WHO), Central African Republic (CAR) Country Office. WHO heightens health response to cholera outbreak in CAR (2019).
7. Asmarino Independent. "URGENT Eritrea: A serious Case of Cholera Outbreak" (2018).
8. Sudan Tribune. "Sudan is free of acute diarrhea: health minister" (2019).
9. Populationpyramid.net. "Population Pyramids of the World from 1950 to 2100" (2018).
10. El Bushra HE., *et al.* "Resilience of Health Systems during a Prolonged Acute Watery Diarrhoea (AWD) Outbreak in the Sudan". *EC Emergency Medicine and Critical Care* 3.1 (2019): 45-51.
11. El Bushra HE., *et al.* "Transparency, Partnerships and Coordination: Key Enablers for Control of An Outbreak of Acute Watery Diarrhoeal Disease (AWD) in the Sudan". *JOJ Pub Health* 4.1 (2018): 555630.
12. El Bushra HE., *et al.* "Political will: necessary but not sufficient for control of an outbreak of acute watery diarrhoea in the Sudan, 2016-2018". *MOJ Public Health* 8.1 (2019): 35-39.

13. World Health Organization (WHO), Global Health Observatory (GHO). Cholera case fatality ratio (%) (2019).
14. Camacho A., *et al.* "Cholera epidemic in Yemen, 2016–18: an analysis of surveillance data". *The Lancet Global Health* 6.6 (2018): e680-e690.
15. Loharikar A., *et al.* "A national cholera epidemic with high case fatality rates--Kenya 2009". *Journal of Infectious Diseases* 208.1 (2013): S69-S77.
16. World Health Organization. Guidelines for drinking-water quality. Volume 1: 3rd ed. Geneva (2004).
17. Nadar K and Yassa F. "Containment of the acute watery diarrhea outbreak in Sudan: the WASH side of the story". IN: Shaw, R.J. (ed). Transformation towards sustainable and resilient WASH services: Proceedings of the 41st WEDC International Conference, Nakuru, Kenya, Paper 2935 (2018): 8.
18. Nagata JM., *et al.* "Criticisms of chlorination: social determinants of drinking water beliefs and practices among the Tz'utujil Maya". *Revista Panamericana de Salud Pública* 29.1 (2011): 9-16.
19. Ministry of Cabinet, Central Bureau of Statistics. "Sudan Multiple Indicator Cluster Survey (MICS)" (2014).
20. World Health Organization. International health regulations. World Health Organization 2008 (2005).

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