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Cholera Outbreak in Yemen: Timeliness of Reporting and Response in the National Electronic Disease Early Warning System

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ABSTRACT

Introduction: In Yemen, the largest cholera epidemic of modern times started in late 2016. By March 2018, more than one million cases had been reported. A national electronic Disease Early Warning System (eDEWS) for infectious disease surveillance was established in 2013. **Aim**: This study assessed the eDEWS's timelines for reported cholera cases. **Methods**: Quantitative data published in eDEWS and the Weekly Epidemiological Bulletin of the Yemen Ministry of Health from March 2013 until March 2018 were analyzed. For assessing the early detection of cholera cases, 262 weekly bulletins were reviewed. The raw data of the immediately generated eDEWS alerts during the first outbreak wave were used to assess response timeliness. **Results**: Reported cholera incidence peaked at 1,698 cases (first wave) in 2016 week 49, and then reached 46,667 cases (second wave) in 2017 week 26. The mean time period between reporting and the first response was 2.85 days. Only 31% of the eDEWS alerts were verified within the first 24 hours, and the majority (83%) were verified within one week. There were major differences in the timeliness between the governorates, ranging from 8%-62% for reporting within the first 24 hours. **Conclusion**: The eDEWS is able to detect and alert health authorities about cholera cases even under conditions of ongoing war and civil war, however, the timeliness of the response needs improvement.

Keywords: Cholera, Yemen, Timeliness, early detection, Surveillance System, Health and Conflict.

1. INTRODUCTION

Yemen is a lower-middle-income country according to the World Bank (1). It has a population of more than 26 million and covers approximately 527,970 square kilometers with a seaboard of about 2,000 kilometers (2). Yemen has a high population growth rate (4.4% in 2013), and the population health indicators are some of the lowest in the world (maternal mortality ratio 148/100,000 and under five mortality rate 53%) (3-5). The country has experienced a long period of civil unrest since the beginning of the Arab spring in 2011. An armed conflict began in March 2015 and continues to date. This on-going conflict has caused a severe humanitarian crisis for the population (5).

The 2018 Humanitarian Needs Overview reports that approximately 16 million Yemenis need humanitarian assistance to access safe water, basic sanitation and hygiene facilities, and 11.6 million of these are in acute need (7). Even prior the current war, only 59% of the population had access to improved drinking water and this figure has decreased to 54 % since the start of the conflict (6). Prolonged population displacement, infrastructure disruption and the worsening water and sanitation conditions have all contributed to one of the worst cholera outbreaks in modern history (7, 8).

Cholera is a disease of acute watery diarrhea caused by the bacterium Vibrio cholera which is usually transmitted through infected water (9, 10). Cholera is clinically diagnosed based on the WHO case definition and confirmed in a laboratory when Vibrio cholera O1 or O139 is detected in a patient's diarrhea or vomitus (11, 12). The current cholera outbreak has become a major public health issue in Yemen. A total of 1,111,653 cases and 2,400 deaths were reported up to

	WHO
A case of cholera should be suspected when (clinical case definition)	"in an area where the disease is not known to be present, a patient aged 5 years or more develops severe dehydration or dies from acute watery diarrhoea; in an area where there is a cholera epidemic, a patient aged 5 years or more develops acute watery diarrhoea, with or without vomiting." *
A case of cholera should be considered confirmed when (standard case definition)	"Vibrio cholera 01 or 0139 is isolated from any patient with diarrhoea." *
	* WHO, 2018 http://www.who.int/cholera/technical/en/.
	eDEWS
Suspected Cholera	Any person aged five years or more with severe dehydration or death from AWD [acute watery diarrhoea].
Cholera alert thresholds	Alerts generated automatically by reporting at least one case from any sentinel site. Outbreak alerts generated by the surveillance coordinator after verification of the alerts Require either at least one lab-confirmed cholera case or a cluster of six or more AWD in a single locality.
	CDC
Timeliness	"The speed between steps in a public health surveillance system" **.
	**CDC 2001-MMWR 50

Table 1. Definitions of epidemiological terms used in this research

March 2018 (13). The outbreak is directly related to conflict in the country and associated damage to infrastructure. However, in principle, it is possible to control such an outbreak through public health measures including early detection, immediate reporting, and timely and effective responses (14-15).

Timeliness is a performance indicator that is widely used to evaluate diseases surveillance systems since it reflects the time delay between sequential steps in the public health surveillance process (16). For instance, a study conducted in Italy evaluated the timeliness of data reported for viral hepatitis to a surveillance system from 2009 to 2012 and found wide delays between surveillance steps resulting in 79 days as a median duration between interview of patients and reporting to central level (17).

2. AIM

This study describes the development of the current cholera outbreak in Yemen with a focus on the ability of the electronic Disease Early Warning System (eDEWS) to identify changes in disease trends and determine the timeliness of the system's response to immediate notifications (alerts) during the outbreak.

3. METHODS

This study assessed the eDEWS's timelines through an analysis of quantitative data published in the Weekly Epidemiological Bulletin of the Ministry of Health (MOH) in Yemen (supported by WHO) from March 2013 until March 2018. For assessing early detection for cholera reporting, a total of 262 weekly bulletins were reviewed. For assessing the timeliness of responses, the raw data of the eDEWS's immediately generated alerts (notifications) during the first wave of the outbreak was used. A total of 1,034 cholera alerts were generated in the system as immediate alerts. The laboratory results were obtained from the cholera line-list from Oct 2016 to March 2018. See definitions in Table 1.

Analytical method: We employed descriptive trend analysis to examine the trend of suspected cholera cases from March 2013 – March 2018 using Microsoft Excel. To determine the eDEWS's timeliness, the mean delay time and the difference in time between case reporting and first verification time were calculated and categorized using SPSS 25. The eDEWS is an interface system based on mobile phones that collects data electronically on a weekly base. It is aimed at early detection and a timely response to infectious disease outbreaks. eDEWS was established by the MOH and the WHO country office in Yemen to strengthen the public health disease surveillance system. eDEWS implementation started in March 2013 in 98 sentinel health facilities of 4/22 governorates (provinces) as a pilot project and was extended in October 2013 to cover 247 health facilities in 10/22 governorates. The next surveillance phase started in 2015 when 408 health facilities from six new governorates were added. In 2016, the last six governorates were included and the system was installed in a total of 1,982 health facilities. In 2013, the system started to report on 16 infectious diseases and by 2017, included 31 infectious diseases (18).

Timeliness	Frequency	%
Response within 24 hours (1 day)	323	31.2
Response within 48 hours (2 days)	229	22.1
Response within 72 hours (3 days)	97	9.4
Response within a week	208	20.1
Response within a month	58	5.6
No data provided for the response	119	11.4
Total	1034	100

Table 2. Distribution of alerts according the timeliness of the first response in eDEWS during the first wave of the cholera outbreak 2016 week 39 to 2017 week 15

At each of the participating health facilities, there is an eDEWS focal person who is responsible for data collection from the clinical services' daily registration book. Each Saturday, all collected data are entered into the eDEWS system using a mobile android application, except for six diseases requiring immediate notification (acute watery diarrhea, measles, acute flaccid paralysis, acute haemorrhagic fever, diphtheria, and pertussis). Every focal person uses a personal identification code and password to enable identification at district, regional or ministry levels. At health facilities, diseases monitored by eDEWS are diagnosed by clinical case definitions. eDEWS generates automatic alerts (notifications) based on various alert thresholds for specific diseases. One alert may include a single case or multiple cases. All weekly reports are initially validated

by the surveillance coordinator at the governorate level (e.g. SMS, phone call or field visit) and then continuously validated at the central level (MOH). For an alert on immediately notifiable diseases, validation should happen within 24 hours from the system's report. The final weekly report should be published and distributed by email within 48 hours of the health facility's reporting deadline, which is Monday of the following week.

4. RESULTS

From the start of the eDEWS system's implementation until the end of 2015, a total of 43 suspected cholera cases were reported; however, none was confirmed as a true cholera case.

Figure 1 shows the number of suspected cholera cases during the first wave of the outbreak from 2016 week 39 to 2017 week 15, which included 25,152 cases and 1,034 alerts. A few scattered cases had already been reported in 2016 weeks 25 (2 cases), 28 (19 cases) and 37 (3 cases). Most of the early cases were reported from one governorate (Albaidha) and none was confirmed. However, in the following weeks, a large proportion of confirmed cases were from the Albaidha governorate. Cholera cases increased gradually until 2016 weeks 49-51 (e.g. 1,698 cases in week 49), and then declined.

Figure 2 shows the number of suspected cholera cases during the second wave of the outbreak from 2017 week 16 to 2018 week 12, which included 953,421 cases and 20,912 alerts. The number of cases increased sharply from 220 cases in 2017 week 16 to 2,426 week 18 and 8,812 week 19. A first peak occurred during 2017 week 26 with 46,667 cases, and a second peak was observed during 2017 week 38 with 35,500 cases. The number of cases then declined gradually to 9,613 by 2017 week 52. This trend of continuously decreasing numbers continued in early 2018.

Timeliness of The First Response

In the first wave of the cholera outbreak, the mean time between reporting and the first response was 2.85 days (SD + 6.089). Table 2 presents the timeliness of the first response to the cholera alerts. Only about one third (31%) of the generated alerts were verified within the first 24 hours, while the majority (83%) were verified within one week.

The majority of the 1,034 cholera alerts in the first wave of the outbreak were verified by SMS (4.4%), phone call (45%) or field visits (40.6%) (Figure 3). There were major differences in the timeliness of reporting within the first 24 hours between the governorates, ranging from 8% in Abyan to 62% in Aden, and major differences in the proportion of the means of verification between the governorates. For example, a field visit was the main mean of verification in Sana'a city and Sana'a governorate (92%) while neither Shabwah nor Al-Dhale'a reported a field investigation as a means of verification during the first wave of cholera outbreak (Figure 4).

Laboratory Findings

The laboratory investigations (standard culture methods and rapid tests) were done on periodic samples from suspected cholera cases of the outbreak. The stool samples were collected from 84% of the total alerts in the first wave. During the first wave of the outbreak, 142/358 (40%) of selected suspected cases were confirmed by stool culture and 106/514 (21%) by rapid. In the second wave 1,130/3155 (36%) of selected suspected cases were confirmed positive Vibrio Cholera by stool culture.

5. DISCUSSION

The cholera outbreak adds to the burden of the health system in Yemen, in addition to war injuries and deaths, are the consequences of dysfunctional health services and the high prevalence of malnutrition (19). More than one million people have been directly affected by cholera to date. This outbreak has become the largest cholera outbreak in the world, even larger than the one in Haiti with a total number of 815 thousand cases from 2010-2017 (20).

Since the last cholera outbreak in Yemen, in 2011, which had 31,789 cases (21,22), no confirmed cases were reported until the establishment of the eDEWS in 2013. During the first three years of the eDEWS system, several cholera alerts were generated by eDEWS, but none were verified except two cases reported in early 2015 and after the beginning of the conflict. The first case occurred in 2015 week 25 in Dhamar, and the second case in week 2015 week 26 in Amran. Both these cases could not be investigated in the laboratory since the patients died before this was possible (23, 24).

The eDEWS is designed as an early warning system for epidemic-prone diseases (25). The system collects data from the health facilities. Although eDEWS is not the only source of data collection in an outbreak of an infectious disease, it is important for the early detection of newly emerging cases. In this study, eDEWS detected 97% of the total cases reported in the first wave and 87% of cases in the second wave of the Yemeni cholera outbreak. This shows that the eDEWS functions as a reliable and sensitive surveillance system in Yemen.

In general, data provision in surveillance systems should be followed by immediate public health action, which is particularly important for epidemic-prone diseases. With regard to cholera, the health system should respond within 24 hours to an alert. However, this study showed that alert action followed in 24 hours only for 31% of the cases, which demonstrates a major problem with the system's timeliness. Moreover, there were major differences in response timeliness among provinces. The timeliness of responses to inform the regional and national health authorities are major issues in many countries. For example, in Ghana, a study showed that timeliness remains a problem although there has been an improvement in completeness (26). Another study, in the USA, found a significant difference in response delay times compared to the standard 24-hour mean time (27).

6. CONCLUSION

We have shown that the eDEWS is able to detect and alert health authorities about cholera cases even under the conditions of ongoing war and civil war, but response timeliness needs improvement.

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