



Epidemiological Features of Cholera in Hodeidah, Yemen 2017: A Retrospective Study

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Received: 04 December 2024. Accepted: 29 June 2025. Published: 30 June 2025.

Abstract

Background: Cholera, a severe diarrheal disease caused by *Vibrio cholerae* (*V. cholerae*), continues to pose a significant global health threat, particularly in regions experiencing war and humanitarian crises. The 2017 cholera outbreak in Hodeidah, Yemen, disproportionately impacted vulnerable populations, particularly children under five. Systemic challenges such as inadequate water sanitation, poor access to healthcare, and deteriorated infrastructure, exacerbated by ongoing war, contributed to the outbreak.

Objective: This study aimed to describe the epidemiological features of cholera outbreak in Hodeidah, Yemen, 2017 (Second Wave).

Methods: The study was designed in a retrospective study and included 17,821 cases at the Diarrhea Treatment Center (DTC) in collaboration with the Center of Tropical Medicine and Infectious Diseases (CTMES), Al-Thawra Public Hospital Authority, the study utilized both descriptive and inferential statistical methods to analyze demographic characteristics, geographic distribution, dehydration severity, and patient outcomes. Statistical Packaging for Social Sciences (SPSS) software was employed for data analysis, with findings presented in tables for clarity and interpretation.

Results: The results showed that males were 7,946 cases (44.6 %) and the females constituted 9,875 cases (55.4 %). Severe dehydration was observed in 41 % of cases, underscoring the demand for intensive care resources. Urban districts, particularly Al Hali, Al Hawak, and Al Mina, accounted for 87 %, reflecting stark disparities in healthcare access. The overall attack rate (AR) in Hodeidah was 0.53 %, while in urban districts was reported 2.4 % and rural districts was 0.08 %. The case fatality rates (CFR %) were 0.22 % in urban areas and 0.24 % in rural areas while the overall CFR was 0.22 %.

Conclusion: The study emphasizes that cholera remains a serious public health threat in Yemen, especially in Hodeidah, where war and a fragile healthcare system worsen the crisis. Women are disproportionately affected due to greater exposure to contaminated water. Urban districts like Al Hali, Al Hawak, and Al Mina report the highest number of cases, while rural areas face higher death rates due to limited healthcare access. The DTC maintained a CFR below 1%. The study calls for improved water sanitation, expanded healthcare access, vaccination programs, and stronger disease surveillance.

Keywords: Cholera, Outbreak, Epidemiological Investigation, Hodeidah, Yemen

1. Introduction

Cholera, a severe diarrheal disease caused by *Vibrio cholerae*, (*V. cholerae*) remains a pressing global health issue, particularly in regions impacted by war and humanitarian crises. It thrives in conditions of poor sanitation, limited access to clean water, and inadequate public health infrastructure, exacerbating its rapid spread and devastating impacts. Yemen's recent history reflects these challenges, with the country experiencing one of the world's largest cholera outbreaks, especially during the 2017 epidemic [1, 2]. The cholera outbreak in Yemen, particularly in Hodeidah, has been a significant public health concern since 2016, peaking between September and December 2018. The attack rate was notably high in Al Hali district, with children under five disproportionately affected, comprising 34.4 of cases [2-4]. Despite its severity, case fatality rates remained low (0.07–0.1) due to effective case management in cholera treatment centers [3, 4]. The outbreak occurred amidst Yemen's ongoing civil war, which caused the collapse of healthcare systems and deteriorated water and sanitation infrastructure. Cholera rates also increase dramatically during floods compared to non-flood periods [5]. These factors created optimal conditions for cholera transmission, with a significant correlation observed between war intensity and cholera attack rate (AR) [6, 7]. Forecasting models predicted the epidemic peak around week 26 of 2017, estimating a cumulative the AR of 700,000–914,000 cases by the outbreak's

end [8,9]. Understanding the epidemiological and clinical characteristics of cholera in Hodeidah during this period is crucial. This report aimed to describe the epidemiological features of cholera outbreak in Hodeidah, Yemen, 2017 (Second Wave).

2. Methodology

2.1. Study area, setting and design

Hodeidah, Yemen's fourth-largest governorate, spans the coastal plain of Tehama and includes densely populated urban districts such as Al Hali, Al Hawak, and Al Mina. The While other districts considerate Rural area. The region's vulnerability to cholera is heightened by malnutrition, displacement, and inadequate access to clean water and sanitation services. [10, 11].

2.2. Outbreak investigation

This investigation adhered to WHO and CDC guidelines, incorporating comprehensive data collection, reviews, and assessments to understand and manage the cholera outbreak in Hodeidah. The key steps included:

2.2.1. Preparation: The response team, consisting of trained medical staff. Th staff included epidemiologists, , internal medicine (nephrology) , infectious diseases , nursing , pharmacists , and medical laboratory analyst , re-habitation of diarrhea treatment center (DTC) , hemodialysis , prepared essential resources,

including diagnostic tools, rehydration solutions, and protective equipment to ensure effective outbreak management.

2.2.2. Establish the existence of an outbreak: confirmed unusual increase in cases of cholera.

2.2.3 Outbreak confirmation: A cholera cases were confirmed by National Center of Public Health Laboratories (NCPHL) and Center of Tropical Medicine and Infectious Diseases (CTMID) in Authority of Public AL Thawarah Hospital of Hodeidah, Yemen from May to October 2017 [12].

2.2.4 Verification: cholera cases were confirmed using stool cultures and rapid diagnostic tests, adhering to established world health organization (WHO) protocols [13]

2.2.5 Case Definition: Cases were classified both epidemiologically (as suspected, probable, or confirmed) and clinically (as mild, moderate, or severe) to streamline analysis and response efforts [14].

2.2.6 Data Collection: Comprehensive data, including demographics, symptoms, onset dates, and patient outcomes, were systematically gathered to provide a detailed understanding of the outbreak [10].

2.2.7 Descriptive Epidemiology: Descriptive statistics were employed to analyze trends and geographic distribution, while chi-square tests identified significant associations between demographic factors and cholera outcomes, offering insights into the patterns of transmission [15]. The Statistical Packaging for Social Sciences (SPSS) was used for data analysis. Attack rate (AR %) and Case Fatality Rate (CFR %) were calculated. The number of population in districts of Hodeidah, Yemen based on Yemen : Population estimation [16]

2.2.8 Control Measures: Interventions focused on distributing oral rehydration solutions, providing clean water, and conducting hygiene education campaigns to mitigate transmission and reduce fatalities [17].

2.2.9 Communication: Findings from the investigation were shared with local authorities, including Hodeidah's Public Health Office and non-governmental organizations (NGOs), to ensure coordinated response efforts.

2.2.10 Surveillance: Continuous monitoring was implemented to track the outbreak's progression and enable timely interventions, contributing to reduced mortality rates [15].

3. Results

3.1 Demographic analysis

17,821 patients were diagnosed and reported with AWD, 1:10 of stool samples were collected and confirmed with cholera in laboratory. Other cases were confirmed based on epidemiological link. The results showed that the males represented 55.4 % of cholera cases, compared to 44.6% for females ($\chi^2 = 209.006$; p – value < 0.0001). This disparity may be influenced by sociocultural roles, such as caregiving and water collection, which increase exposure to contaminated water sources. The adults over 20 years were the most affected group, accounting for 44.7 %. Children aged 1–5 years and 6–18 years represented 14.8 % and 33.7 % , respectively ($\chi^2 = 3601.03$; p – value < 0.00001). Table 1 provides a detailed distribution of cholera cases by sex, age group, and residency, showing that urban areas had the highest number of cases .

3.2. Geographic distribution

Urban districts, including Al Hali, Al Hawak, and Al Mina, contributed 88 %, highlighting significant disparities in healthcare access and water sanitation infrastructure. The rural areas accounted for 12 % but had higher case fatality rates of 0.24, likely due to limited access to timely and adequate medical care

Table 1: Distribution of cholera cases by sex and age group (N=17,821)

variables	Number (n)	Percentage (%)
Sex		
• Male	7,946	44.6
• Female	9,875	55.4
Age (years)		
• < 5 years	2,640	14.8
• 6-18 years	6001	33.7
• > 18	9180	51.5
Residency		
• Urban	15,730	88.3
• Rural	2,091	11.7

3.3. Morbidity and mortality

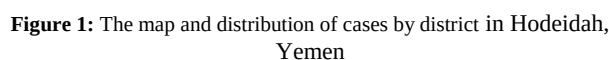
The AR in Hodeidah Governorate was 0.53 %,while in the urban areas was reported 2.4 % , compared to 0.08 % in rural areas. The overall of case fatality rates (CFR %) were 0.22 % , while in urban districts was 0.22 % and 0.in rural districts was 0.24 % , reflecting effective case management strategies despite disparities in healthcare access, Table 2 and Table 3 provide a detailed breakdown of the AR and case CFR for urban and rural districts, illustrating the stark differences between these regions, Figure 1 visually represents the distribution of cases, attack rate, and case fatality rates by district, further emphasizing the geographic variations in the cholera outbreak across Hodeidah.

Table 2: Urban distribution of the AR and case fatality rates (n=15,730)

District	Population	Total Cases	AR (%)	CFR (%)
Al Hali	263,866	7,948	3.01	0.33
Al Hawak	244,508	5,795	2.37	0.09
Al Mina	144,588	1,987	1.37	0.15
Total	652,962	15,730	2.4	0.22

Table 3: Rural distribution of the AR and case fatality rates (n=2,091)

District	Population	Total Cases	AR (%)	CFR (%)
Ad Dahi	84,311	113	1.34	0.0
Ad Durayhimi	86,428	123	1.42	0.0
Al Jarrahi	140,365	33	0.24	0.0
Al Khukhah	53,082	31	0.58	3.2
Al Mansuriyah	69,603	166	2.38	0.0
Al Marawi'ah	202,792	153	0.75	0.0
Al Mighlaf	63,354	41	0.65	0.0
Al Munirah	59,257	10	0.17	0.0
Al Qanawis	112,973	165	1.46	0.6
As Salif	10,020	134	13.37	0.7
As Sukhnah	92,951	178	1.91	0.0
At Tuhayta	109,524	44	0.40	0.0
Az Zaydiyah	149,930	232	1.55	0.4
Az Zuhrah	216,340	8	0.04	0.0
Al Hujaylah	14,758	2	0.14	0.0
Alluhayah	163,584	59	0.36	0.0
Bayt Al Faqih	379,849	96	0.25	0.0
Bajil	270,815	292	1.08	0.3
Bura'	71,179	91	1.28	0.0
Hays	70,501	34	0.48	0.0
Jabal Ras	69,558	4	0.06	0.0
Zabid	243,229	82	0.34	0.0
Total	2,734,403	2091	0.08	0.24



The cholera outbreak in Hodeidah highlighted significant vulnerabilities related to environmental factors, systemic healthcare deficiencies, and socio-economic disparities. Urban districts, such as Al Hali and Al Hawak, experienced high AR due to population density, inadequate sanitation, and insufficient healthcare infrastructure. Conversely, rural areas had lower case numbers but higher fatality rates (CFR = 0.24), likely due to limited healthcare access and delayed treatment [7, 13]. Gender disparities were also evident, as women accounted for 55.4% of cases. This could be attributed to socio-cultural roles that increase their exposure to contaminated water sources, such as caregiving and water collection responsibilities [9]. In terms of age distribution, adults over 20 years old were the most affected group (51.5 %), followed by children aged 6–18 years (33.7 %) and less than 5 years (14.8 %). These findings align with previous studies on cholera outbreaks in war-affected regions, where age-related risk factors are influenced by nutritional status, immunity, and sanitation access

The study highlights that cholera remains a major public health threat in Yemen, particularly in Hodeidah, where war and weak healthcare systems exacerbate the crisis. Women were disproportionately affected due to increased exposure to contaminated water, underscoring the need for stronger emergency medical responses. Urban districts such as Al Hali, Al Hawak, and Al Mina had the highest case numbers, while rural areas recorded higher fatality rates due to limited access to healthcare, emphasizing the need for targeted interventions to bridge the urban-rural healthcare gap. The DTC maintained a CFR below 1%. To prevent future outbreaks, the study stresses the importance of improving water sanitation infrastructure, expanding healthcare access, implementing vaccination programs, and strengthening disease surveillance and rapid response systems. Collaboration between local, regional, and global stakeholders is essential for building a sustainable public health system that can withstand war and future epidemics.

Data Availability
No data were used to support this study.

Conflicts of interest
The authors declare that they have no conflicts of interest.

This work was conducted during our work at CTMID – Al Thawara Public Hospital Authority , Hodeidah ,Yemen .

The studies involving human participants were reviewed and approved by Ethics Committee of Tropical Medicine and Epidemiology Studies of Hodeidah University (CTMES-HU) Hodeidah, Yemen .

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