Determinants of Cholera in Yemen's Conflict Setting

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Determinants of Cholera in Yemen's Conflict Setting

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By

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List of Abbreviations

AWD	Acute Watery Diarrhoea
CFR	Case Fatality Rate
CFR	Case Fatality Ratio
CI	Confidence Interval
CU5	Children Under Five
DFA	De Facto Authorities
DHO	District Health Office
DTC	Diarrhoea Treatment Centre
eDEWS	Electronic Disease Early Warning System
EMR	Eastern Mediterranean Region
EPI	Expanded Program on Immunization
GAM	Global Acute Malnutrition
GARWSP	General Authority for Rural Water Supply Project
GDP	Gross Domestic Product
GHO	Governorate Health Office
GTFCC	Global Taskforce on Cholera Control
IDMC	Internal Displacement Monitoring Centre
HFs	Health Facilities
IDPs	Internally Displaced Persons
IRR	Incidence Rate Ratio
INGOs	International Non-Governmental Organizations
IOM	International Organization of Migration
IRG	Internationally Recognized Government
LCs	Local Corporations
LMICs	Low Middle-Income Countries
LWSC	Local Water and Sanitation Company
MAM	Moderate Acute Malnutrition
MENA	Middle East and North Africa
MoPHP	Ministry of Public Health and Population
MWE	Ministry of Water and Environment
NGOs	Non-Governmental Organizations
NWRA	National Water Resource Authority
OCHA	Office for the Coordination of Humanitarian Affairs
OCV	Oral Cholera Vaccination
OOPs	Out-of-Pocket Expenditures
OR	Odds Ratio
ORS	Oral Rehydration Salts
PiN	People in Need
PLW	Pregnant Lactating Women
RDTs	Rapid Diagnostic Tests
SAM	Severe Acute Malnutrition
SSA	Sub-Saharan Africa
UN	United Nations

UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WFP	World Food Program
WHO	World Health Organization
WASH	Water, Sanitation, and Hygiene
YHNO	Yemen Humanitarian Needs Overview
YHRP	Yemen Humanitarian Response Plan

Abstract

Introduction: Due to the latest civil war, Yemen has undertaken rampant outbreaks, including cholera infectious disease, which has increased the vulnerability of the humanitarian situation in the country. Commencing in October 2016, the initial surge of the cholera outbreak gripped numerous Yemeni governorates, followed by a staggering escalation in 2017. This escalation led to over 1.2 million suspected cases and 2,310 fatalities, translating to a case-fatality ratio of 0.21%.

Objective: To identify and discuss the general environmental, socio-economic, and aggravating risk factors that contributed to the development of cholera in Yemen, and to propose applicable interventions in conflict-affected settings, to reduce the risk of cholera disease.

Methodology: From 2000 to 2023, a comprehensive review encompassed both published and grey literature, utilizing Google search engines in conjunction with local and international NGO websites. Additionally, reports from the MoPHP in Yemen and articles from Google Scholar, VU University, and, PubMed have been utilised. An adjusted analytical framework has been designed to analyse the findings of this review.

Results: This review revealed that general environmental and socio-economic factors, including the fragile health system and poor WASH infrastructure, contributed significantly to the development of persistent cholera outbreaks in conflict settings in Yemen. Aggravating factors to this situation such as overcrowding, due to a growing number of internally displaced people, increased malnutrition rates, and issues related to climate change play a growing role.

Main Conclusions:

1. In Yemen, cholera is an endemic disease with a considerable incidence rate.
2. Even before the onset of the civil war, the conditions were not quite favourable to prevent cholera.
3. The civil war has most probably accelerated the cholera outbreaks.
4. There has been a disturbing gap between requested funding for humanitarian aid (including health) and international donor pledges. This brought further strain on the already weak humanitarian and health systems.
5. Climate change issues cannot be ignored when discussing the development of cholera in recent years. There are more and more droughts coupled with more intensive rainfall; this further constrains the already deteriorated WASH systems.

Thus, specific recommendations were made to the main stakeholders according to their mandates.

Keywords: Cholera, conflict, determinants, Yemen.

Word count: 13,182

Introduction

For almost 14 years, I have dedicated my professional life to Yemen's healthcare sector. During this time, I acquired valuable expertise through a decade-long engagement in the pharmaceutical market and gained four years of hands-on experience in humanitarian work. In my humanitarian role, I successfully managed numerous projects addressing food security, healthcare, and nutrition challenges, in different crisis-affected areas of Yemen. The decision to transition into humanitarian work in 2018, was driven by Yemen's deteriorating humanitarian situation over the past decade.

My journey in the humanitarian sector started with the Yemen Family Care Association (YFCA), a local NGO operating in Yemen. Having worked for local NGOs, I have actively participated in alleviating the suffering of affected Yemenis, in different geographical locations of the country, through numerous humanitarian programs. During that period, I have been completely exposed to the latest deteriorated humanitarian situation in Yemen, particularly the unprecedented cholera outbreaks in the challenging environments where our interventions were conducted.

More than a decade ago, Yemen's Ministry of Public Health and Population (MoPHP) struggled to formulate a proper strategy to strengthen the already deteriorated health system. Unfortunately, the recent deteriorating situation in the country has disrupted the execution of this strategy. Since the 2015 conflict, the healthcare system has swiftly declined, primarily due to the worsening condition of public infrastructure, economic instability, and security challenges. Consequently, the population has endured substantial hardships, resulting in a noticeable rise in mortality rates, especially among vulnerable groups like mothers and children.

Yemen is a primary focus for studying the factors influencing cholera occurrence due to its conflict-affected status. The humanitarian crisis, including the ongoing cholera outbreak, emphasizes the critical need to understand the disease's determinants better. My professional engagement in Yemen, particularly in responding to the cholera outbreak, motivates me to conduct an in-depth analysis of this topic.

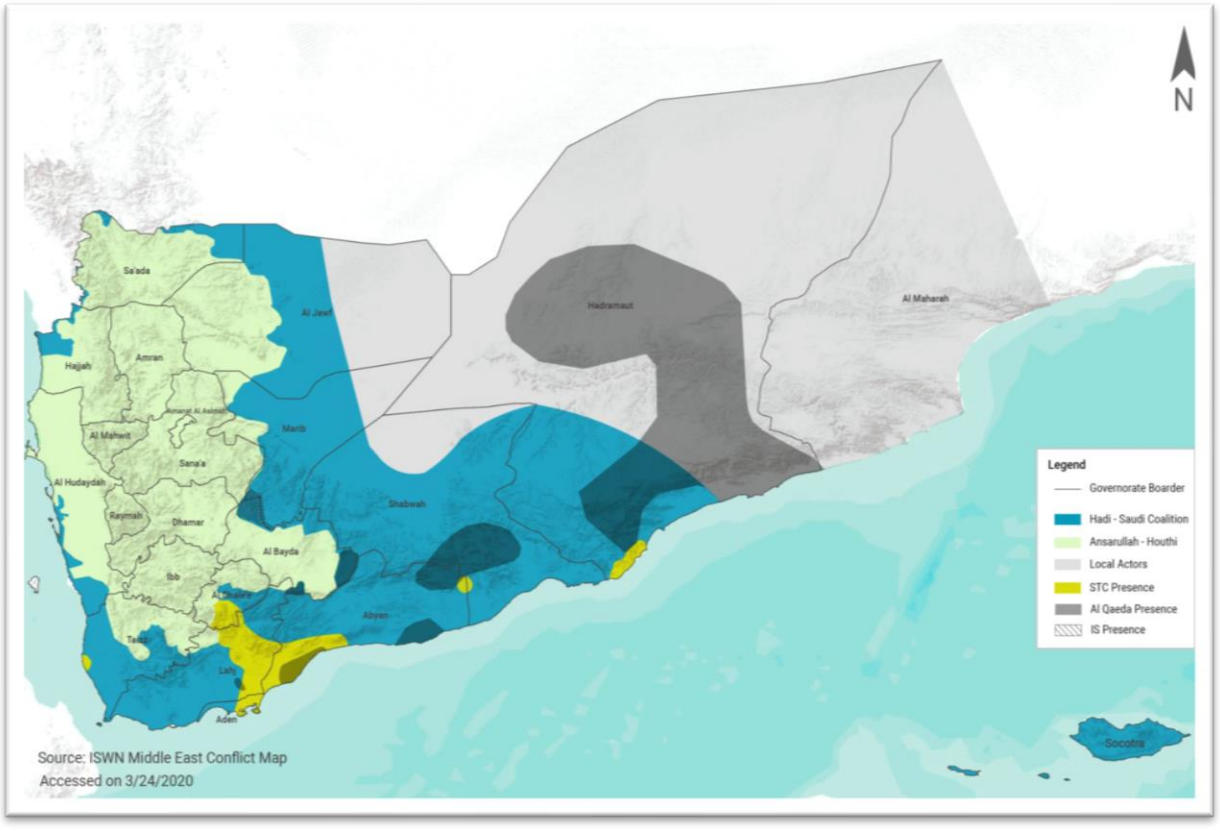
In this study, I seek to examine the main causes of cholera development in conflict-affected Yemen, aiming to generate valuable insights for future response and intervention efforts. A better understanding of the underlying factors, contributing to the cholera problem in the country, would provide informed guidance for decision-making and could enhance response effectiveness. Ultimately, this effort aims to alleviate the suffering of individuals impacted by the cholera outbreaks in Yemen and improve life for all.

Chapter 1: Yemen Background

1.1 Geography

Yemen is in size one of the biggest Arabian countries. Yemen has a strategic and dispensable geographical location among Arab states. Gulf countries surround Yemen from different borders such as Oman and Saudi Arabia to the west and north. From the south side, it borders the Arabian Peninsula while on the south side, the Gulf of Aden and the Arabian Sea share the border (1). The Red Sea and the strategically significant Bab Al-Mandeb Strait form its western boundary (Map 1). According to Yemen Analysis Hup, Yemen's total area is approximately 527,970 square kilometres (1).

Yemen is renowned for its remarkable geographical diversity, encompassing various natural features. While the southern part, under International Recognized (IRG), contains wide areas of deserts, the northern part, under De Facto Authorities (DFA), is well-known for its mountainous nature. Yemen also boasts a picturesque coastline, with coastal regions that showcase the country's beauty and richness (2). Additionally, many islands give Yemen a unique nature (2). The agriculture system in Yemen has been adversely affected by the scarcity of natural water resources, indicating a persistent challenge of insufficient water supplies within the country (3). Yemen consists of approximately twenty-one governorates, each of which is comprised of 333 districts. Within these districts, there are a total of 2,210 sub-districts, as well as an extensive network of 38,284 villages (2).



Map 1. Map of Yemen (1)

1.2 Population

As one of the biggest states in the Arabian Peninsula, approximately 30.491 million individuals are the total population of Yemen in 2021, based on UN data. Per each square kilometre, around 57.8 individuals reside in the country, reflecting the population density. Most of the population resides in rural regions with an estimation of 61.5%, whereas around 38.5% are located in urban areas (4). In 2021 reporting time, the growth rate and fertility rate were 2.4% and 3.8%, consecutively. Meanwhile, it was reported that females at birth showed a life expectancy of 67.7 years while males showed 64.4 years. With an estimation of 38.4%, the age group 0-14 years constitutes the population's highest segment. Additionally, females made up 49.63% of the overall population. Figure 1 reflects Yemen's population pyramid (5).

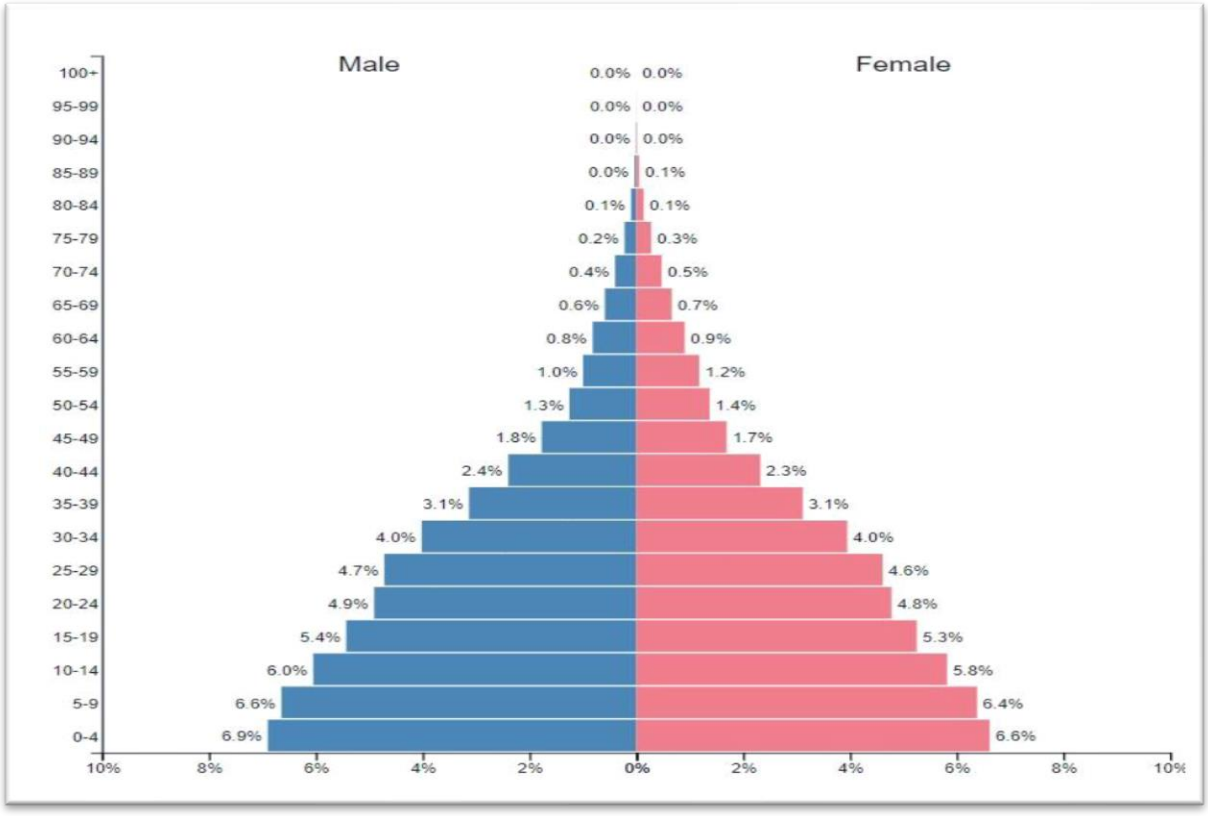
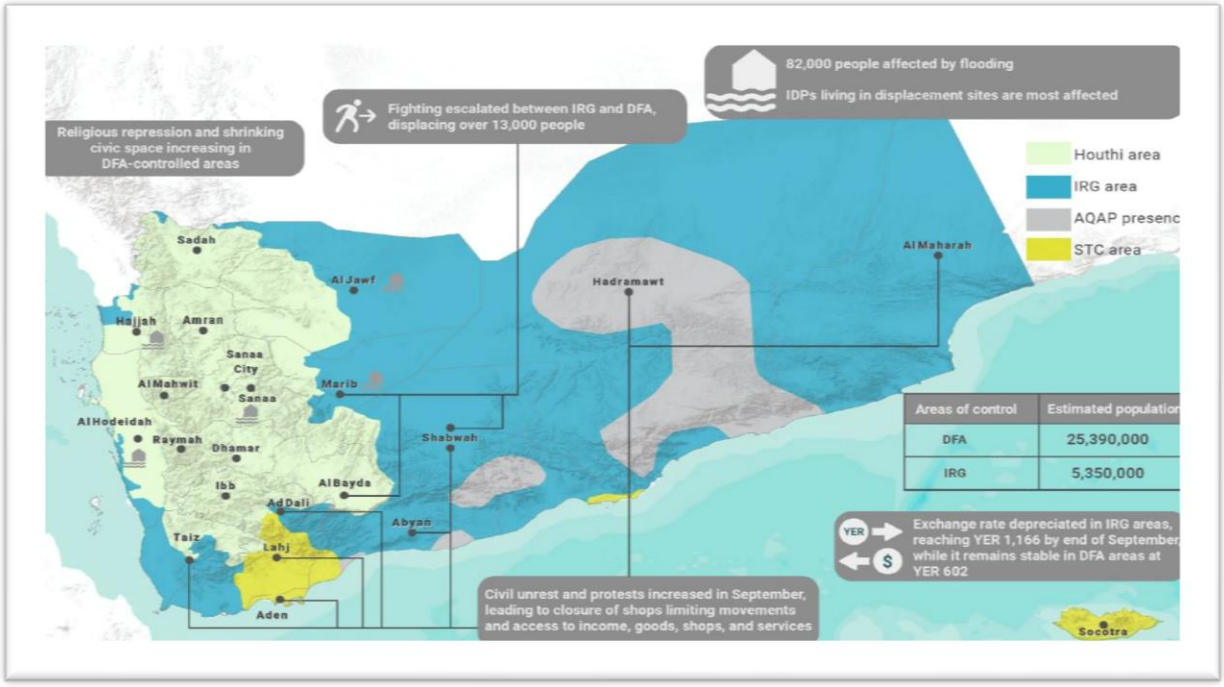


Figure 1. Yemen Population Pyramid (5)

1.3 Politics and Security

After the political unrest in 2011, occurred in Arab nations, a civil war has been broken out throughout Yemen. As a result of this conflict, two distinct and separated local powers emerged in the south and north of the state (6). The power in the north is under the DFA government while the IRG controls the southern part. In addition to the human losses due to civil war, the humanitarian situation in the country has deteriorated, and the country's infrastructure has also suffered significant damage. According to the data provided by the Armed Conflict Location & Event Data Project (ACLED), more than 145,000 innocent human beings have been killed since the broken out of the conflict in 2015 till October 2021 (6).

Yemen has been divided into two distinct parts as a consequence of recent conflicts. The De Facto Area in the north is under the control of the Houthis group while the southern region is governed by the IRG. Map 2 expresses the fragmented areas between conflicted powers in the south and north of Yemen (7). On April 27th, 2022, to address the political unrest about the leadership of the IRG in Yemen, a new president by the name of Rashad Alalimi was elected. This election resulted in the replacement of the previous president, Abduh Rabuh Hadi (8). On the international side, the deteriorated situation in Yemen and the government's inability to handle the unrest, have raised international concerns about the stability of shipping routes through the Bab Al-Mandeb strait. The political tensions between, Iran and Saudi Arabia, have worsened this threat to the strait's security and stability (6).



Map 2. DFA and IRG areas in Yemen (7)

1.4 Socio-economic Situation

At the level of human development, Yemen has shown a low rank of 179th among 189 countries worldwide, based on the Human Development Index (HDI) (9). Even before the conflict, the majority of the Yemeni population, with an estimation of 71%, were suffering from poverty, with women and children being the most vulnerable and affected segments (9,10). Seven years of internal conflict have prominently affected the socioeconomic status of Yemen and its capacity to deliver public services, including healthcare. The conflict has hurt the oil industry, one of the main sources of the economy. The increased cost of imported oil has also had a profound adverse effect on economic activities (1).

Before the conflict, commercial imports used to play a crucial role in Yemen’s economy and contributed to 80%-90% of the essential requirements (1). As a consequence of the conflict that started in 2015, both critical industries of oil and liquefied natural gas (LNG) have been affected, leading to a reduction in crude exports. The drop occurred to fuel prices in 2019 worldwide has

reduced Yemen's revenues from oil exportation. Thus, to facilitate the importation of essential commodities including food and fuel, the Yemeni government has relied on other alternatives such as Saudi Arabia's support, international aid funding, remittances, and limited sources of foreign currency (1).

To support the import of essential commodities, to provide salaries to public and military sectors, and to contribute to stabilizing the depreciated Yemeni Rial (YER), the Kingdom of Saudi Arabia has contributed by injecting $2.2 billion in funding through letters of credit in 2019 (1). This financial support has played a crucial role in stabilizing the Yemeni riyal, which experienced a significant depreciation to nearly 900 YER per US dollar (USD) in October 2018. Following the support, the local currency averaged between 500 to 600 YER to the USD in 2019. Saudi Arabia has not yet committed to renewing its funding for 2020, and Yemen's cash reserves are depleting (1).

Lately, by December 2021, the Yemeni Rial (YER) has undertaken a depreciation of more than 100 percent against the USD in the IRG areas, compared to the previous year (11). However, in November of the same year, the implementation of a foreign exchange auction mechanism, along with the appointment of new management for the central bank in Aden on December 6, 2021, played a crucial role in reversing this downward trend. As a result, the rial has stabilized since January 2022 (11). Figure 2 shows the exchange trend in both conflicted authorities (Sana'a and Aden).

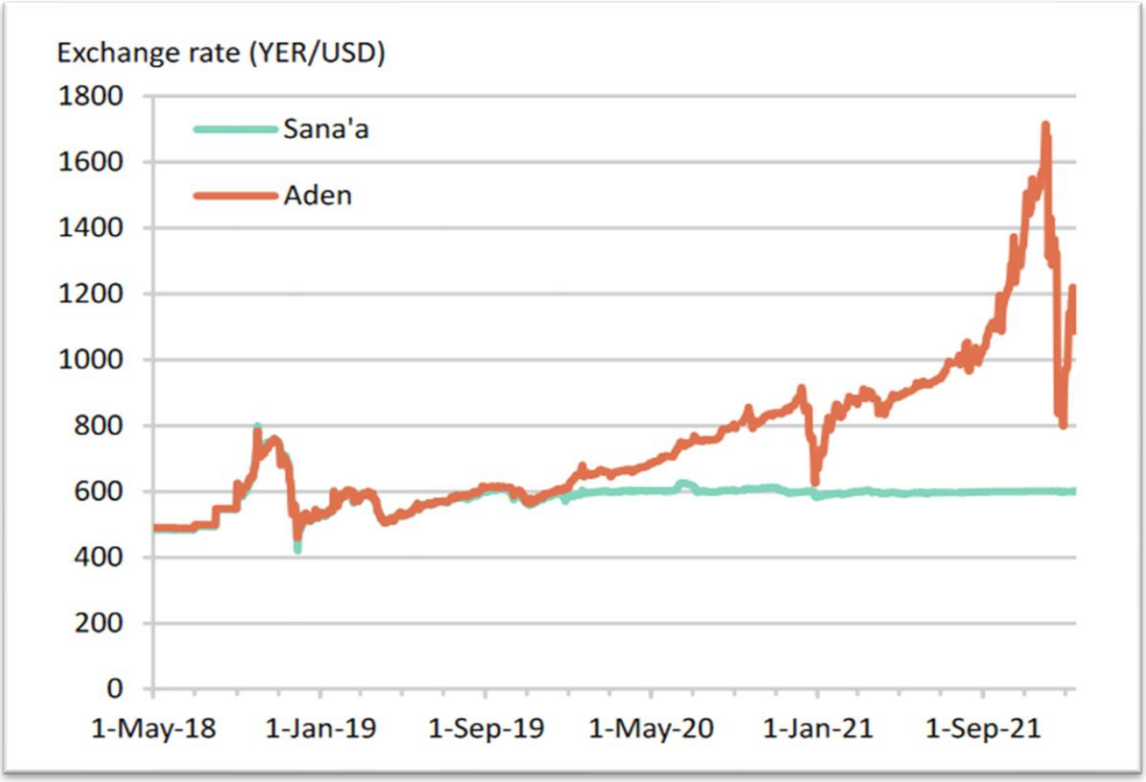


Figure 2. Exchange rate trend in Yemen (Sana'a and Aden)

1.5 Socio-cultural Situation

Yemen is a predominantly Islamic country, where around 98% of its population follows the Islamic faith. The official language spoken is Arabic and Islam is the primary religion practiced in the nation (12). Within the Muslim population, the majority consists of Sunnis, accounting for about 65% of the total, while Shias make up approximately 35% (12). The tribal culture with its power in the north side of Yemen has profoundly affected this area's culture of the country. In contrast, tribal impact is relatively less pronounced in the southern parts of the country. Due to the fragile state of the government system and persistent internal conflicts, tribal leaders have exerted their power over national institutions (12).

The education system in Yemen has suffered dire consequences due to the ongoing conflict (13). The impact has been devastating, leading to widespread disruptions in schooling and leaving a lasting toll on the cognitive, emotional, and mental well-being of Yemen's 10.6 million school-age children, based on the Education Cluster's leadership, the UNICEF. Over the span of seven years, approximately one in four schools, totalling 2,916 educational institutions, have suffered destruction, partial damage, or repurposing for non-educational use. This disintegration of the education system has introduced formidable obstacles to creating a conducive learning environment and securing future opportunities for Yemen's young boys and girls (13).

The education system in Yemen faces significant challenges as two-thirds of teachers, approximately 172,000, have been irregularly paid since 2016 or have left to seek other income sources (13). The COVID-19 pandemic worsened the situation, causing schools to close for much of the 2020-2021 academic year, affecting nearly 5.8 million students, including 2.5 million girls (13). Even before the pandemic, two million children were already out of school. Multiple factors like displacement, distant schools, safety concerns (including explosive hazards), lack of female teachers (80% male), and inadequate WASH facilities contribute to increased vulnerabilities. Girls drop out at risk of early marriage and domestic violence, while boys are at higher risk of recruitment into armed groups (13).

For a long time, women and men used to suffer from gender-relevant issues in Yemen. Women faced many challenges such as sexual harassment, forcing them to marry at early ages, female genital mutilation, denial of inheritance, and mobility restrictions (14). Before reaching adulthood, approximately 32% of Yemeni women are compelled by their families to enter marriage, especially prevalent in the northern governorates due to cultural norms and beliefs (14). Following the outbreak of the civil war in 2015, these practices have escalated, resulting in a notable surge in incidents of physical assault, an uptick in cases of sexual abuse, a rise in instances of psychological abuse, an increase in resource denial, and elevation in occurrences of child marriages by 50%, 35%, 25%, 17%, and 11%, respectively. Additionally, men face specific protection threats, such as forced recruitment, arbitrary detention by armed groups, and the constant risk of injury or death (14).

1.6 Health System and Cholera Outbreaks

In practice, two 'Ministries of Health' are currently operating in Yemen: one in the north under De Facto authority and the other in the southern area under IRG's power (11). The health system in Yemen operates under three levels, primary health care, secondary, and tertiary (11). Healthcare services in Yemen are provided by both the public and private sectors across the nation. Within the public sector, various entities such as facilities under the MoPHP, Police, and Military hospitals

contribute to the delivery of healthcare. On the other hand, the private sector encompasses a diverse range of stakeholders, including both profitable and non-profitable organizations, as well as local and international NGOs. These private healthcare entities have been working in collaboration with the public sector, offering complementary services to fulfill the healthcare requirements of the Yemeni population (15).

Conflict in Yemen has profoundly affected healthcare indicators. Although updated demographic and health indicators data are lacking in the country, an analysis of trends before the conflict already revealed a fragile health system. Reporting of the health system has been affected due to the civil war (11). This led to a scarcity of dependable data, notably concerning metrics like maternal and infant mortality rates (11). In the year 2021, projections indicate a Maternal Mortality Rate (MMR) of 500 per 100,000 live births, alongside an Infant Mortality Rate (IMR) of 51 per 1,000 live births (23,24). UNICEF's estimations highlight the raised vulnerability of mothers and babies caused by the conflict (16). These challenges arise from an overcrowded health system that is strained by conflict-related outbreaks like cholera (17).

In Yemen, the conflict has emerged as the third primary contributor to mortality and the second leading factor behind premature death (18). During the period from 2007 to 2017, deaths resulting from conflict increased by around 70%. Ischemic heart disease and neonatal disorders continue to be the top two causes of death during this period, highlighting the impact of a weakened healthcare system (18). The diarrheal diseases come as the sixth cause of death in 2017. Limited data exist on communicable diseases, which are undoubtedly worsened by the conflict and the significant damage inflicted on healthcare infrastructure (18). Figure 3 expresses Yemen's top causes of death from 2007 to 2017.

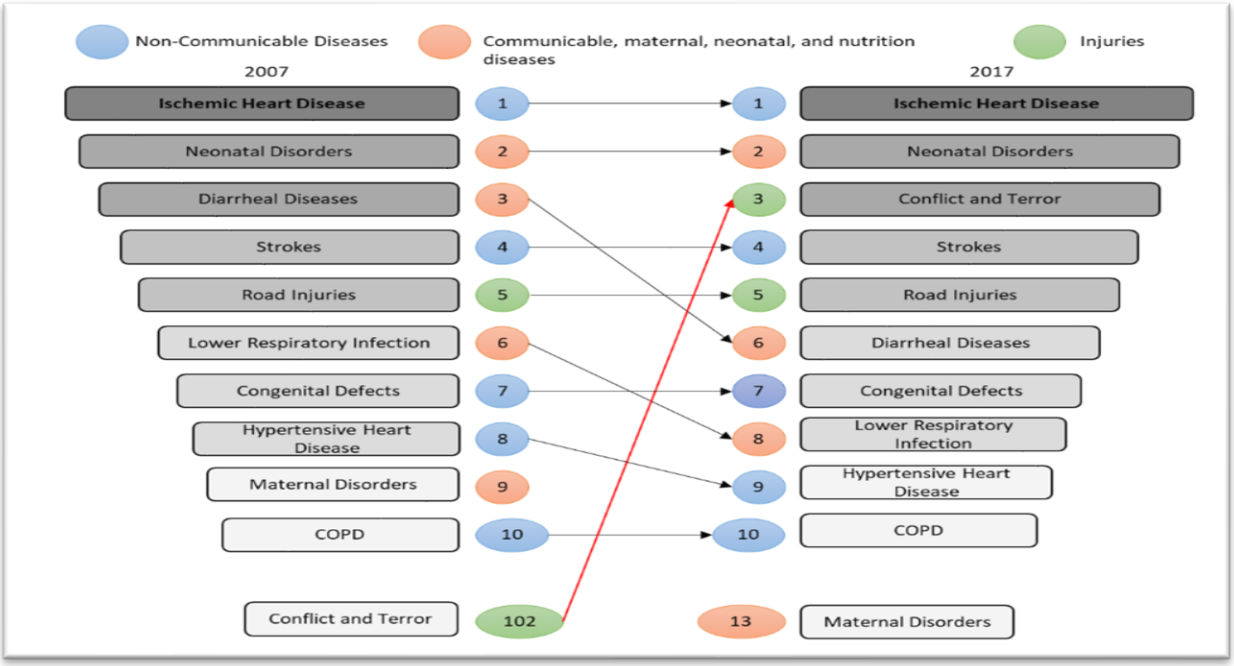


Figure 3. Top causes of death in Yemen, 2007-2017 (18)

The ongoing conflict in Yemen has severely weakened essential social services, particularly the fragile healthcare system, which has been further compounded by the COVID-19 pandemic (11). The pandemic has placed immense strain on the already weak healthcare infrastructure, leading to a high estimated mortality rate of approximately 25% (11). Additionally, routine health services, including immunization and maternal care, have suffered due to reduced demand. Flight suspensions resulting from COVID-19 have disrupted the movement of humanitarian personnel, hindering their support. The global economic downturn caused by COVID-19 has also prompted major donors to reduce or suspend aid in Yemen, creating uncertainty in the delivery of health services (11).

The two separated and conflicted areas of Yemen have undertaken two outbreaks of cholera after the civil war in 2015 (19). From 2016 to April 2017, depicted in Figure 4, the first wave has stricken the country leading to a total of 2,510,806 suspected cholera cases and 3,981 related deaths, resulting in a case-fatality ratio (CFR) of 0.16% (19). Thereafter, the second wave spanned from April 2017 to December 2020, depicted in Figure 5, leading to approximately 2,484,979 suspected cholera cases and 3,852 related deaths, maintaining the same CFR of 0.16%. Remarkably, 26.6% of the total reported cases during the period from October 2016 to December 2020, were children under 5 (CU5). This highlights the vulnerability of young children to the disease (19).

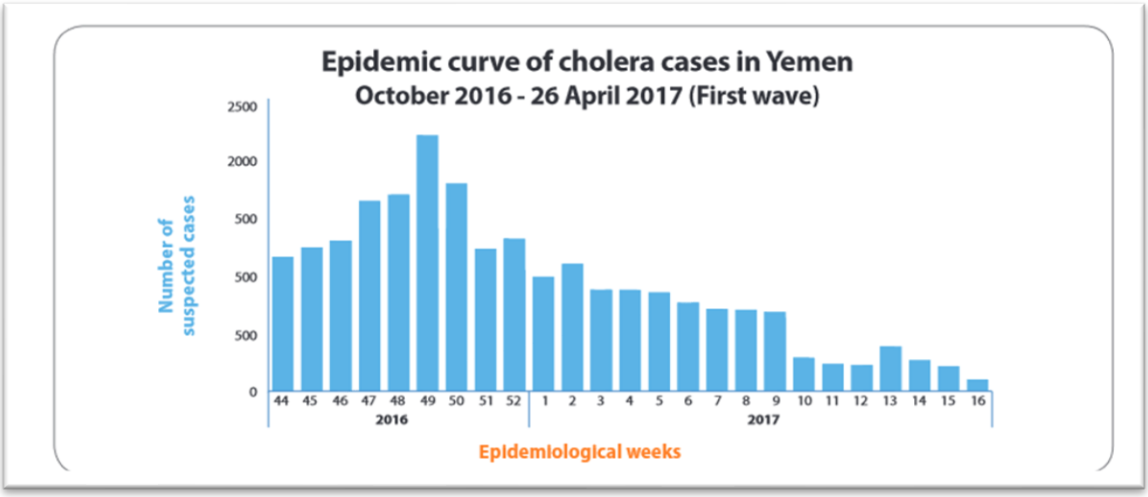


Figure 4. Epidemic curve of cholera cases in Yemen, October 2016 - 26 April 2017 (First wave) (19)

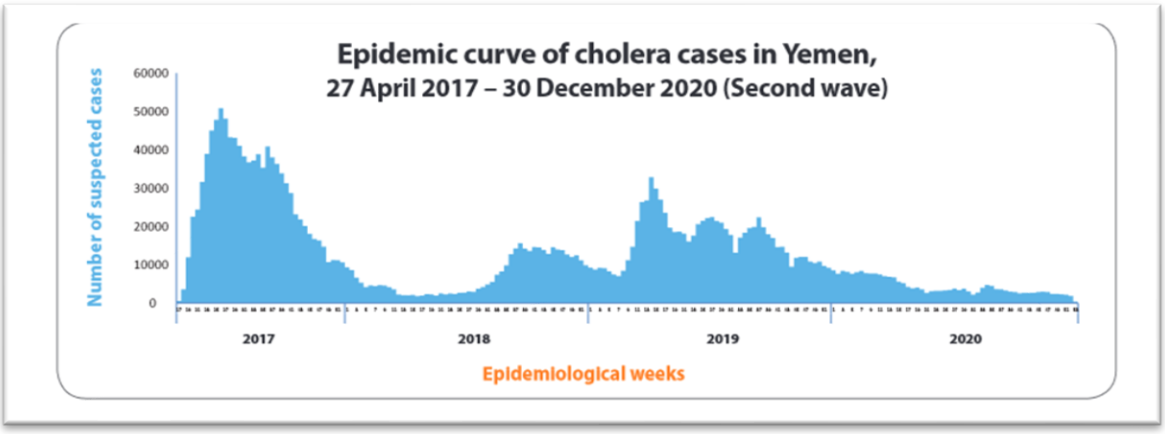


Figure 5. Epidemic curve of cholera cases in Yemen, 27 April 2017 - 30 December 2020 (Second wave) (19)

1.7 Cholera and Water, Sanitation and Hygiene (WASH)

Yemen is plagued by a diverse array of infectious diseases, exacerbated by the inadequate WASH infrastructure in the country. According to an assessment conducted in 2020, a staggering 65% of the population faces urgent WASH needs. Treated water sources could be accessed by only 30-40% of the Yemeni people (20). Around half of the Yemeni individuals have access to satisfactory sanitation services, while a mere 30-40% can avail of adequate hygiene services. In rural regions, the predicament becomes notably demanding as government agencies frequently fall short in delivering sanitation services. The shortcomings in WASH infrastructure have led Yemen to grapple with a considerable incidence of AWD and cholera, rendering it vulnerable to waterborne disease outbreaks, particularly in its rural areas. The lack of proper WASH facilities contributes significantly to the spread of these infectious illnesses, further burdening the already strained healthcare system (20).

Chapter 2: Cholera Definition, Problem Statement, Justification, Objectives, and Methodology

2.1 Cholera definition

Cholera is an infectious disease characterized by acute watery diarrhoea (AWD) caused by the bacterium Vibrio cholerae. The disease can rapidly develop if neglected without treatment, which can exacerbate the patient's status and might lead to death (25,26). Numerous manners could help to transmit the bacterium, including contaminated water and food (27). Infected individuals may exhibit mild symptoms or remain asymptomatic after contracting the bacterium. Mild cases can be effectively treated with oral rehydration solution (ORS). Typically, individuals who consume contaminated water or food will start showing symptoms within 12 hours to 5 days. Both adults and children are susceptible to being affected by this outbreak (26).

Vibrio cholerae, the causative agent of cholera, can be divided into two primary serogroups: V. cholerae O1 and V. cholerae O139. The seventh cholera pandemic in 1961 was attributed to the O1 serogroup, which comprises both the classical and El Tor biotypes. Within the O1 serogroup, there are three distinct serotypes: Ogawa, Inaba, and Hikojima. During an epidemic, all three serotypes can coexist as the bacteria can mutate between them. The second serogroup, V. cholerae O139, was first identified in India back in 1992. It is essential to acknowledge that aside from human transmission, water, certain molluscs, fish, and aquatic plants can also serve as potential reservoirs for Vibrio cholerae (21).

A description of the cholera case has been shaped in consideration of disease prevalence. Table 2 succinctly outlines the fundamental elements of this case definition, as defined by the WHO, Global Task Force on Cholera Control (GTFCC), and Médecins Sans Frontières (MSF) (21–23).

Table 1. Cholera case definition (21,22)

WHO case definition	In an area where the disease is not known to be present.	Severe dehydration or death from acute watery diarrhoea in a patient aged 5 years or more.
	In an area where there is a cholera epidemic.	Cholera should be suspected in all patients with acute watery diarrhoea.
Global Task Force on Cholera Control (GTFCC) Case definition	In areas where a cholera outbreak has not been declared.	Any patient aged 2 years and older presenting with acute watery diarrhoea and severe dehydration or dying from acute watery diarrhoea
	In areas where a cholera outbreak is declared.	Any person presenting with or dying from acute watery diarrhoea
Médecins Sans Frontières (MSF) case definition	In an area where there is a cholera epidemic.	Any patient presenting with 3 or more liquid stools and/or vomiting for the last 24 hours.

2.2 Cholera Clinical Features

A high mortality rate, ranging from 20% to 50%, could be attributed to a fatal outbreak of cholera and management is a must with such a disease (21). The mortality rate could be pushed under 2% with appropriate treatment. Cholera's incubation period can sustain from a few hours to 5 days. When ingested, most of the bacteria will be destroyed by stomach acids. Some surviving bacteria can invade the intestinal cells, multiply and produce an enterotoxin. When attached to intestinal cells, this toxin triggers the release of balanced fluids into the intestines, leading to the onset of diarrhoea. In moderate cases of cholera, individuals may experience a moderate loss of fluid and subsequent dehydration (21).

Infection with cholera remains asymptomatic in 80% of cases, while 20% of those affected experience pronounced manifestations of the illness (21). This can lead to a fluid loss ranging from 10 to 20 liters daily (21,22). As the dehydration worsens with the infected patients, many complications can be manifested such as severe thirst, mucous membrane dryness, sunken eyes, rapid pulse, low blood pressure, lethargy, and decreased urine output; patients may develop hypovolemic shock (21,22). Often, cholera also leads to electrolyte imbalances and acidosis such as hypokalaemia (low potassium levels), hyponatremia (low sodium levels), and hypocalcaemia (low calcium levels) (21).

2.3 Global Burden of Cholera

Commencing in 2021, there has been a noticeable upswing in cholera occurrences worldwide, coupled with a broader dissemination of the disease across various regions (24). Within that same year, outbreaks of cholera were recorded in 23 different countries, predominantly concentrated within the WHO Regions of Africa and the Eastern Mediterranean. This concerning trend persisted in 2022, as more than 29 countries reported cholera cases or outbreaks (Figure 6). As of November 30, 2022, 16 of these countries experienced prolonged outbreaks. Disturbingly, many of these nations reported higher case numbers and a more significant case fatality ratio (CFR) compared to previous years. In 2021, the average cholera CFR globally was 1.9%, with Africa bearing a higher burden at 2.9% (24).

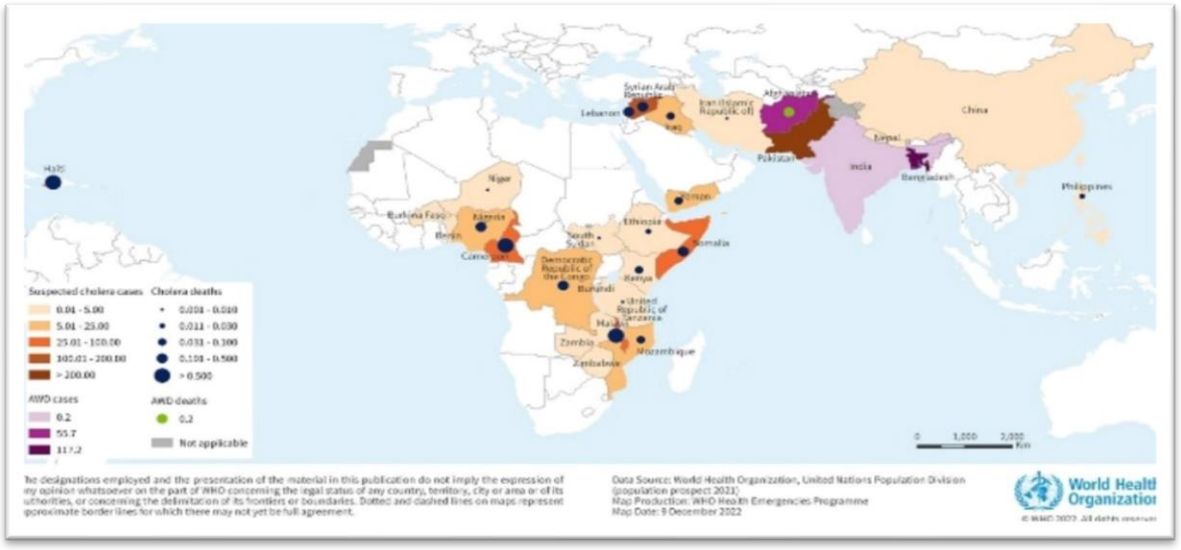


Figure 6. The incidence of cholera cases (including estimated cases of AWD) per 100,000 population reported to the WHO, Between January 1 and November 30, 2022 (24)

Globally, an estimated 1.3 to 4 million cases of cholera are observed yearly with approximately 21,000 to 143,000 deaths (25). Nations embroiled in internal conflicts face an increased susceptibility to enduring epidemics for an extended period (26). In the Eastern Mediterranean Region (EMR), cholera occurrence increases, according to data from WHO (27). In LMICs, diarrhoea has contributed primarily to disease and mortality. Worldwide, approximately 1.7 billion cases of diarrhoea occur, leading to 760,000 deaths among children below the age of 5 (28). The annual number of cholera cases in endemic nations (Figure 7). In the realm of the 69 countries afflicted by cholera, it became evident that roughly 2.9 million cases were documented, resulting in around 95,000 deaths. The gravest impact of cholera has been notably concentrated within the Sub-Saharan Africa (SSA) region (24).

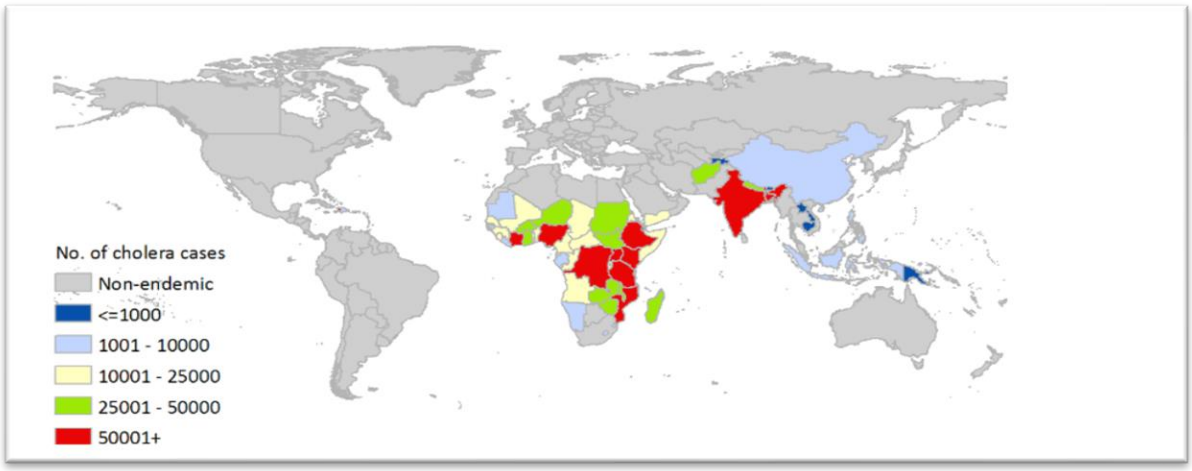


Figure 7. Annual number of cholera cases in endemic countries (25)

2.4 Problem Statement and Justification

During complex humanitarian emergencies, like the war in Yemen, conducting comprehensive analyses of health outcomes and related factors becomes extremely challenging (29). The elevated risk of disease morbidity and mortality makes it difficult to gather primary data, while medical resources, personnel, and hospital bed capacity are severely constrained (29). Additionally, real-time analyses are hindered by the scarcity of available data, reduced laboratory testing capacity, and the disruption or absence of health infrastructure caused by wartime events like bombings and explosions (26).

In 2022, 23.4 million people in need (PiN) required humanitarian assistance and protection, based on the Humanitarian Needs Overview Report (HNO), in Yemen. Among these populations, approximately 12.9 million persons were in acute need of humanitarian assistance (30). According to the HNO Report 2022, food insecurity, malnutrition, limited healthcare services, water and sanitation needs and protection were the main drivers behind this deteriorated situation. Alarmingly, a high portion of the population, estimated 19 million individuals, needed food assistance, with 7.3 million in acute need (30). In 2022, while 21.9 million people have struggled to access critical health services, approximately 17.8 million people have also suffered to meet their clean water and basic sanitation needs in Yemen. The civil war has crucially affected WASH services infrastructure in the country. A lack of goods and supplies was experienced because of the imposed siege on seaports (30).

Recently, there was a severe cholera outbreak throughout the country, based on WHO and UNICEF reports (31). From April 2017 to October 2018, there were an estimated 1,236,028 cholera cases, including 2,556 deaths (case fatality rate - CFR - 0.21%) (32). Based on data from the WHO, during the period from 2009 to 2019, Figure 8 below, expresses the incidence of cholera-reported cases and CFR in Yemen. Despite that CFR has shown a decline over the years, the suspected reported cases of cholera still pose a threat and increased significantly in 2019 compared to previous years (33). Based on WHO and UNICEF, the outbreak was the worst of its kind in the world (33).

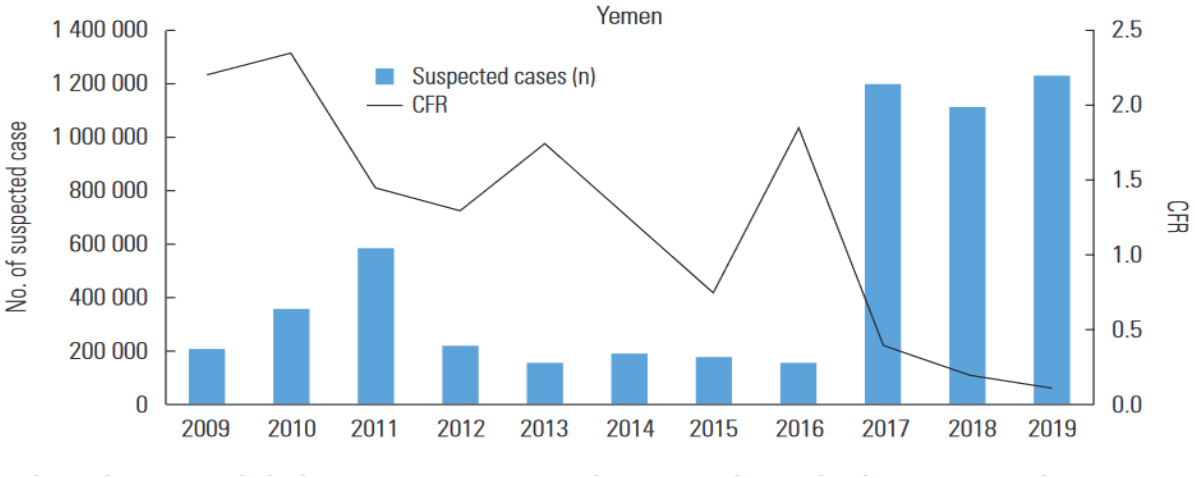


Figure 8. Total number of suspected cholera cases in Yemen and associated case-fatality rate (CFR) from 2009 to 2019 (33)

The number of studies conducted on contributing factors to cholera development in Yemen's conflict setting is still limited. The fragile surveillance and early warning system, alongside the scarcity of standardized data collection methods, have contributed to these limitations. Significant knowledge gaps persist concerning the primary risk elements contributing to cholera within a context marred by conflict. In light of these knowledge deficiencies, the author endeavors, through this review, to recognize, scrutinize, and deliberate upon the possible catalysts for cholera emergence. This encompasses a thorough examination of environmental and socio-economic factors, alongside an exploration of exacerbating influences stemming from the ongoing civil war in Yemen. The primary objective is to provide vital insights for Yemen's policymakers and humanitarian entities, shedding light on the intricacies and gravity of the cholera crisis within the nation. This effort seeks to identify actionable avenues for addressing the situation effectively.

2.5 Objectives

2.5.1 General Objective

To contribute to the understanding of the key determinants of the cholera public health problem in Yemen and to propose applicable interventions in the Yemen conflict-affected context to alleviate the risk of mortality due to cholera.

2.5.2 Specific Objectives

- To analyse and discuss the environmental and socio-economic factors that contributed to the development of cholera in Yemen.
- To identify aggravating factors due to the civil war, that has exacerbated cholera endemic in Yemen.
- To provide applicable recommendations to the policy makers and to the humanitarian stakeholders including the local and international NGOs, and public and private health actors to guide them in their intervention strategies.

2.6 Methodology

2.6.1 Research Strategy

This thesis is the result of a descriptive literature review. The literature used included: published studies, peer-reviewed scientific articles, and grey literature. Humanitarian reports from MoPHP, local and international NGOs including United Nations Entities such as UNOCHA, UNICEF, and WHO have been utilized. Supportive search engines such as VU library, PubMed, Google Scholar, and NGOs journals have been used also for more searches and useful information using a combination of keywords such as "cholera", "Yemen", "SSA", "LMICs", "determinants", "conflict", "outbreak" and "communicable diseases". To nurture the research, snowballing techniques have been followed from the initial articles and reports.

Keywords were used to search through ReliefWeb and Humanitarian Response Platforms for more grey literature on epidemiological reports. Useful articles were selected based on topic relevancy. The literature search was performed in the English language. To better find more useful and relevant data, the Arabic language has been used to get relevant information from published reports by MOH, which might not be available in English. For inclusion criteria, the search period will be considered from 2000 to 2023. To the best knowledge of the research paper's author, findings from other countries with the same humanitarian contexts have been considered.

The search strategy is summarized, (Table 3).

Table 2. Search table strategy

Key Words					
OR	Cholera	AND	Determinants	AND	Global
	Diarrhoea		Risk factors		LMICs
	Communicable disease		WASH		Yemen
	Waterborne disease		Infrastructure		Eastern Mediterranean Region
	Outbreak		Socioeconomic		Sub-Saharan Africa
	Endemic disease		Political		South Sudan
	Infectious disease		Conflict		
			War		
			Education		
			Environment		
			Rural		
			Urban		
			Fragile		
			Emergency		
			Challenges		
			Humanitarian		
			Response		

Search Platforms
Google Scholar, VU online library, PubMed, ReliefWeb, UN agencies reports, NGOs, Humanitarian Response, Journals, and websites.

2.6.2 Conceptual Framework

An adjusted conceptual framework (Figure 9) has been designed, to examine the various factors contributing to the development of the cholera outbreak in Yemen, due to the latest civil war. The author has adjusted a relevant framework (annex 1), due to its logical and comprehensive approach to analyse the factors associated with cholera endemicity. It emphasizes the identification of broader environmental and socio-economic factors, coloured in blue as shown in the adjusted framework, that has played a major role in the emergence of the disease. These factors entail the fragile health system, socio-economic, WASH components, education, and socio-cultural factors.

Additionally, the framework considers aggravating factors, with red colour in the adjusted framework, which has further intensified the development of cholera. These factors include the presence of internally displaced people (IDPs), malnutrition rates, as well as the impact of the conflict on humanitarian stakeholders' accessibility to affected regions. Given its growing importance in recent years, climate change is also included in the aggravating factors. The author focused on key factors, that seem to have a strong association with the cholera outbreak in Yemen. By utilizing this model, the aim is to present the relevant factors in a coherent framework that also shows their interactions and relationships. This framework may also prove to be a sound basis for formulating relevant health policies and interventions.

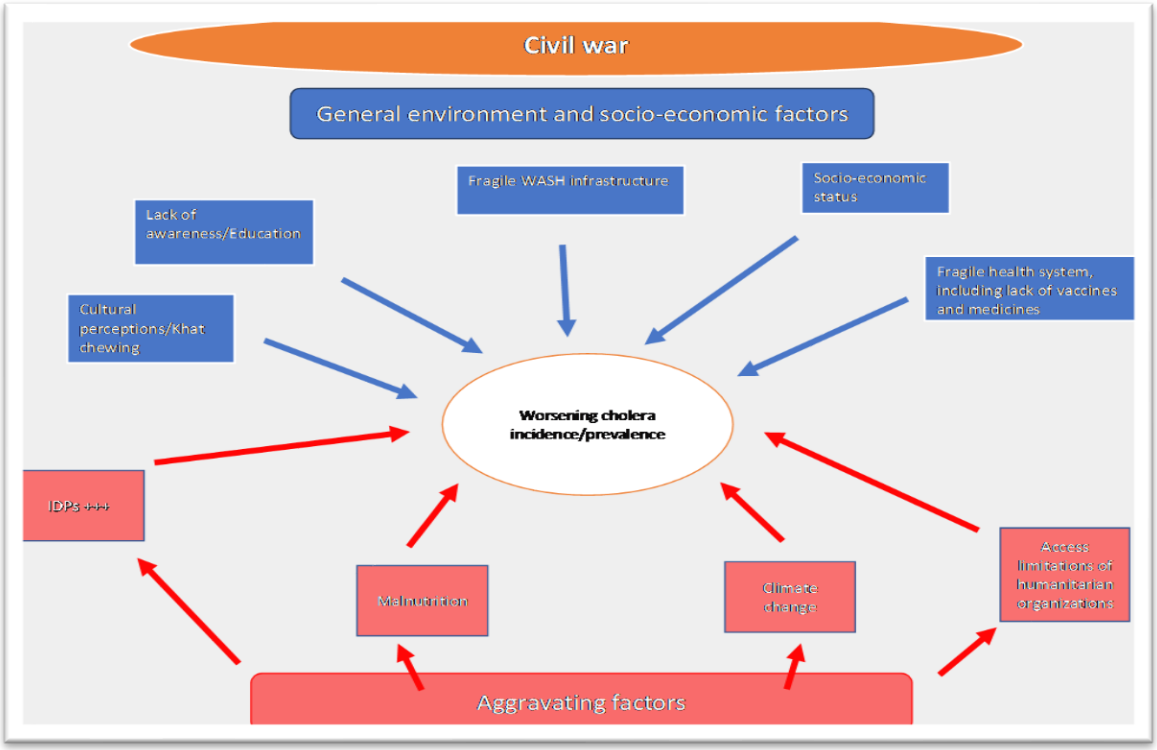


Figure 9. The adjusted framework for risk factors of a cholera outbreak

2.6.3 Limitations of the Study

The ongoing conflict in Yemen has had a profound impact on the health surveillance system, resulting in a scarcity of data concerning communicable diseases, including the cholera outbreak. Restrictions on access to outbreak reports by humanitarian stakeholders have further constrained the scope of this research. Notably, the National Demographic and Health Survey (DHS) in Yemen was last conducted in 2013, and no subsequent updates have been made available to date. Given these constraints, the author of this thesis has been compelled to rely on existing national and international NGO reports to gather data and establish the problem statement. Despite these limitations, the author aims to offer valuable insights into the factors influencing the occurrence of cholera in Yemen. The ultimate objective is to present well-founded recommendations to policymakers and humanitarian stakeholders for guiding future responses and interventions.

Chapter 3: Findings

3.1 Environmental and socio-economic factors

3.1.1 Fragile health system

The civil war has severely impacted Yemen's already fragile health system. This has led to a notable deterioration in the operational health infrastructure, including hospitals and primary care centers. Access to healthcare services has become increasingly challenging for the population due to several barriers, including poor governance, limited funding, shortages of human resources, and a lack of essential equipment and medical supplies (34). Yemen's standing in global governance assessments reflects the severity of the situation. Consistently ranking among the lowest-ranking countries out of 168 nations evaluated for public sector corruption (35). The country faces additional hurdles in effectively managing epidemics. In this regard, Yemen's capacity to handle an epidemic is ranked 193rd out of 195 countries. This situation has compounded the already dire health challenges faced by the Yemeni population, making it exceedingly difficult for them to access proper healthcare during these turbulent times (36).

Estimating the precise prevalence of cholera in Yemen's region poses challenges, due to under-reporting and the presence of weak surveillance systems, making it difficult to ascertain the true burden of the disease. In 2013, in collaboration with WHO, the leader of the health cluster in Yemen, Yemen's health authorities introduced Electronic Disease Early Warning System (eDEWS) (37). Within all governorates of Yemen, around 1990 public and private HFs, were included under the established eDEWS to ensure swift and efficient data collection and analysis, to respond effectively to the rampant outbreaks (37). The recent civil war has exacerbated the burden on the already fragile eDEWS as only 51% of HFs are still fully functional and around 274 HFs have been destroyed. Many HFs have been forced to close down due to inadequate funding, shortages of essential medicines, and a shortage of healthcare personnel (38).

Around 8.8 million Yemeni people encounter significant challenges when trying to access HFs. To reach a properly functioning primary HF, these individuals must travel for more than 30 minutes. For over 42% of the population, the closest hospital is located at a considerable distance. Accessing primary care HFs proves to be a demanding task for the majority of patients, with approximately 82% relying on walking to the nearest facility. However, for more than 50% of the population, this means walking for more than 30 minutes. The burden of long and often difficult journeys to receive necessary medical attention further compounds the already strained healthcare system in Yemen, impacting the well-being of its citizens (34). Table 4 reflects the difficulties faced by people accessing HF.

Table 3. Average traveling time required by people to the nearest HFs (39)

Travel time	Nearest PHC with vehicle access	Nearest PHC by foot	Nearest Hospital with vehicle	Nearest hospital by foot
< 30 minutes	69.4%	55%	37.4%	17%
< 60 minutes	90.9%	82%	57.6%	32%
< 120 minutes	98.4%	97%	80.5%	52%

The health financing system in Yemen heavily depends on private out-of-pocket (OOP) spending, while public expenditures on health are limited, comprising only 2% of general government expenditures in 2015 (40). Before the conflict, there was a noticeable diminish in public health expenditure as a percentage of its GDP, which has minimized from 1.16% to a mere 0.43% during 2005-2015 (34,40). At the same time, spending on public health services as a percentage of total health expenditures has undertaken a prominent drop from 22.5% reaching 10.5%. On the other hand, a slight increase in the OOPs spending increased from 74% to 81%. Figure 10 shows the current sources of health expenditures with OOPs being considered the main source of health spending (34). The rising medical treatment costs and substantial transportation expenses for patients, especially those residing in rural areas, have created significant barriers to accessing health services (41).

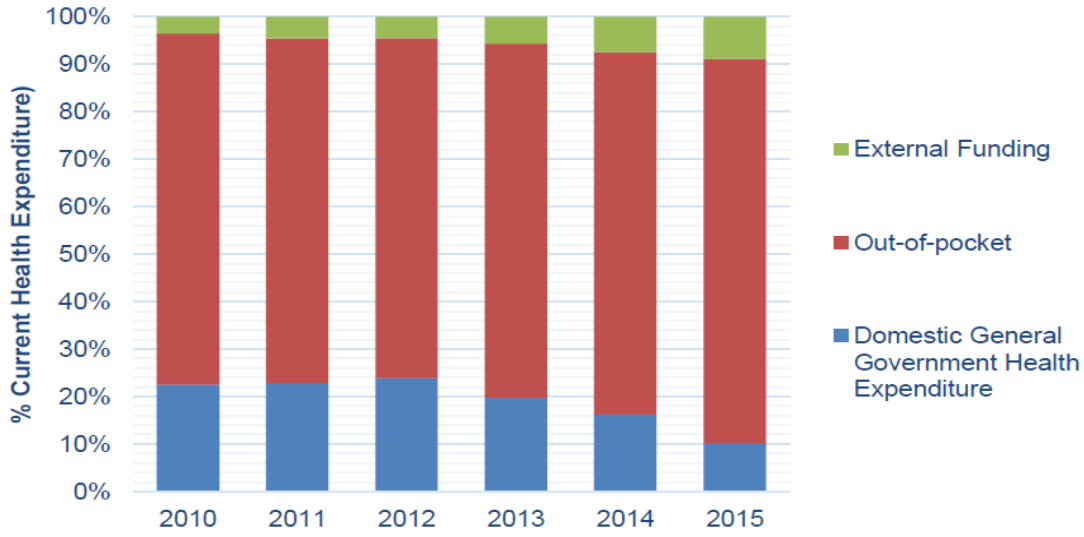


Figure 10. % current health expenditures by source (34)

One of the main financial supports to the deteriorated humanitarian situation in Yemen is the funds provided by international donors (Figure 11) (11). The funds aid injected into the country is pooled into the Yemen Humanitarian Fund (YHF), which is managed and supervised by the NU Office for the Coordination of Humanitarian Affairs (OCHA) (42). International donors support the YHF, led by OCHA, which provides direct funding to local and international humanitarian partners. Through the provision of international funds to YHF, the delivery of essential humanitarian assistance to vulnerable populations in the affected regions could be facilitated. Aligned with the Yemen Humanitarian Response Plan (YHRP), the YHF focuses on addressing critical priorities and urgent needs, effectively expanding the reach of humanitarian aid in the country (42). Map 3 shows active humanitarian partners per governorate.

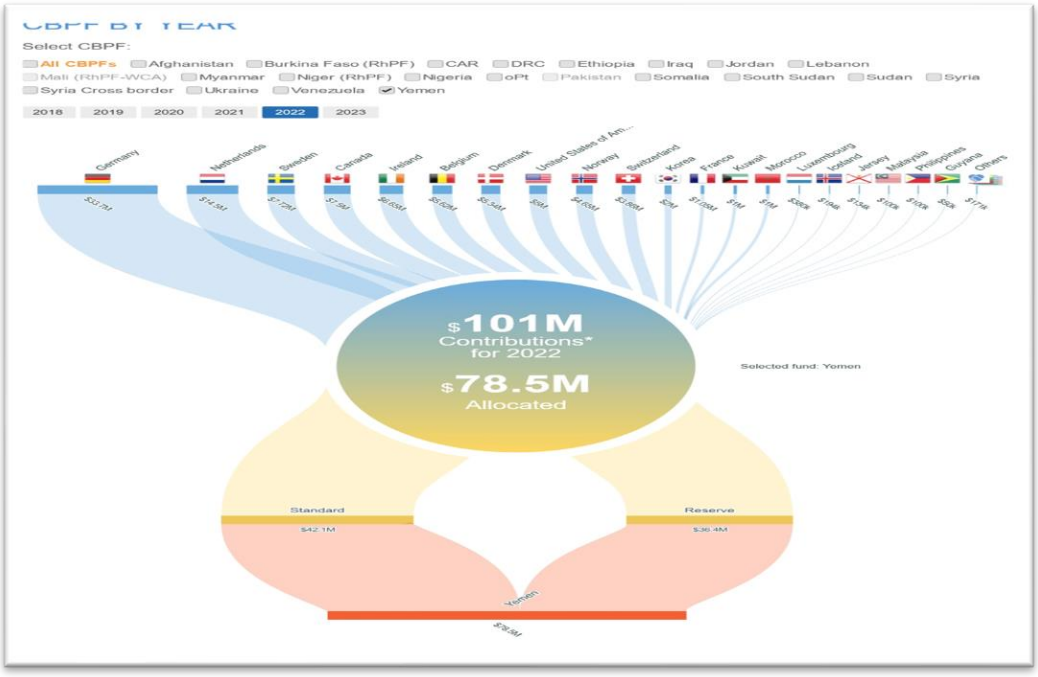
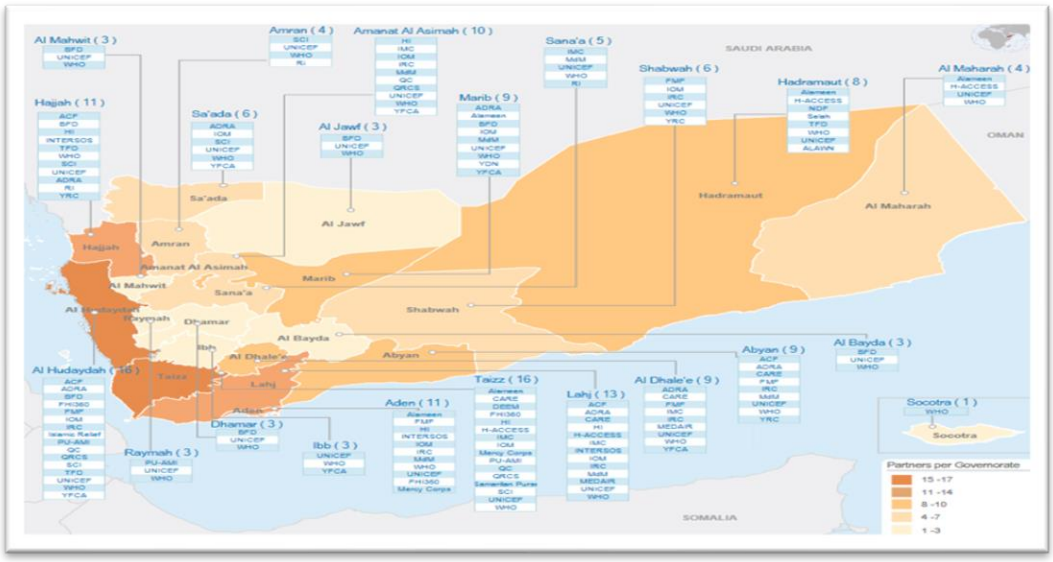


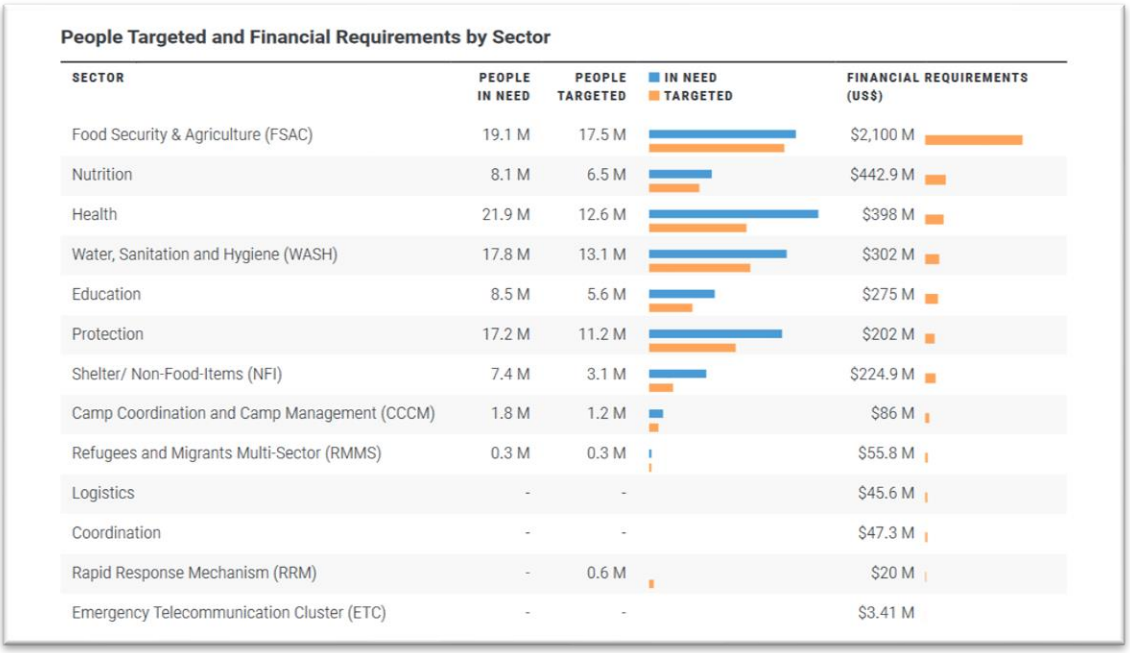
Figure 11. International donors to CBPF in Yemen in 2022 (42)



Map 3. Health Cluster Partners per Governorate in Yemen (43)

Based on YHRP 2022, the humanitarian actors in the country faced a severe shortage of funding from international donors. While $4.2 billion of funds have been requested by actors in 2022, only $1.4 billion was received, leaving a significant funding gap of approximately 70.2% of the total requested amount, this shortage has prominently affected the humanitarian intervention programs including food security, health, nutrition and WASH (44). In 2022, in addition to local authorities, around 200 humanitarian stakeholders were operating the humanitarian interventions in all sectors including 130 national NGOs, 58 international NGOs, and 12 UN agencies, across 333 districts of

Yemen. All of these humanitarian partners have faced difficulties in implementing the humanitarian programs due to a lack of funds (44). Figure 12 shows the population targeted and the financial requirements of each sector.



People Targeted and Financial Requirements by Sector

SECTOR	PEOPLE IN NEED	PEOPLE TARGETED	IN NEED / TARGETED	FINANCIAL REQUIREMENTS (US$)
Food Security & Agriculture (FSAC)	19.1 M	17.5 M		$2,100 M
Nutrition	8.1 M	6.5 M		$442.9 M
Health	21.9 M	12.6 M		$398 M
Water, Sanitation and Hygiene (WASH)	17.8 M	13.1 M		$302 M
Education	8.5 M	5.6 M		$275 M
Protection	17.2 M	11.2 M		$202 M
Shelter/ Non-Food-Items (NFI)	7.4 M	3.1 M		$224.9 M
Camp Coordination and Camp Management (CCCM)	1.8 M	1.2 M		$86 M
Refugees and Migrants Multi-Sector (RMMS)	0.3 M	0.3 M		$55.8 M
Logistics	-	-		$45.6 M
Coordination	-	-		$47.3 M
Rapid Response Mechanism (RRM)	-	0.6 M		$20 M
Emergency Telecommunication Cluster (ETC)	-	-		$3.41 M

Figure 12. People Targeted and Financial Requirements by Sector (45)

Many HFs in Yemen have suffered to maintain functionality due to a shortage of human resources in health (16). As per the WHO, Yemen has an average of only 3 doctors and 7 hospital beds available for every 10,000 people (18). The current ratio falls significantly below the WHO's recommended minimum of 22 health workers per 10,000 people, which is considered essential to provide even the minimum basic health coverage (19). In approximately 18% of the districts across Yemen, there is a lack of doctors, and a majority of health personnel have not received salaries for more than 2 years. This challenging situation has led to a significant brain drain as healthcare professionals seek better opportunities elsewhere, exacerbated by unfavourable working conditions (20). Figure 13 shows the health workers who received incentives in 2021.

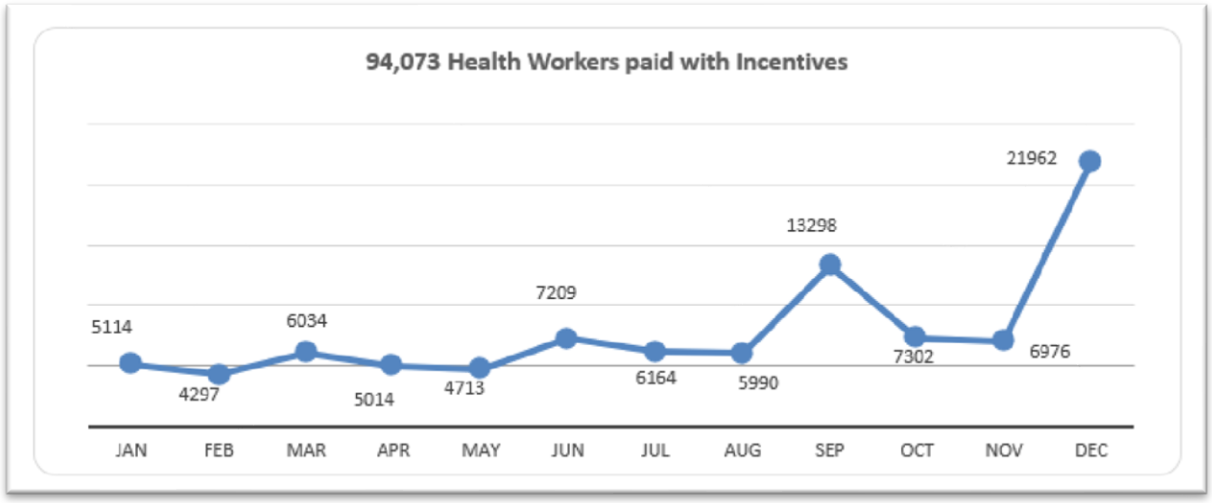


Figure 13. HEALTH WORKERS PAID WITH INCENTIVES IN 2021 (46)

The conflict has imposed a prominent impact on the fragile health system and is leading to a scarcity of essential supplies necessary for the response efforts at the local level, particularly against the cholera outbreak (47). The availability of laboratory reagents and Rapid Diagnostic Tests (RDTs) remained consistently under threat, posing a significant shortage (48). The existence of crucial medical supplies, including essential items for cholera response, like Oral Rehydration Solution (ORS), gloves, and intravenous fluids, faced significant limitations due to the staggering influx of these items into the country. Reports from Yemen indicated that the rate of supplies entering the country was only a third of what it was before the conflict due to the blockage of borders (49,50).

During the duration from 2016 to 2018, Yemen's average ratio of children's vaccinations trend has experienced a regular downturn, based on the WHO. Despite the vaccination rate averaging 75.1% in 2016, it has experienced a steady decline in 2017 and 2018, with vaccination coverage of 73.7% and 71.6%, respectively (51). The continual low vaccination rates in Yemen have affected the children's quality of health. This has contributed to Yemen's high newborn loss of life, as depicted in Figure 14. The persistently low vaccination rates in Yemen could be attributed to numerous elements. The ongoing struggle has precipitated the devastation of clinical centres, making it hard to deliver important vaccination services to all regions in the country. Additionally, the logistics and problems related to maintaining the cold chain for vaccines have in addition hindered vaccination efforts in Yemen (52).

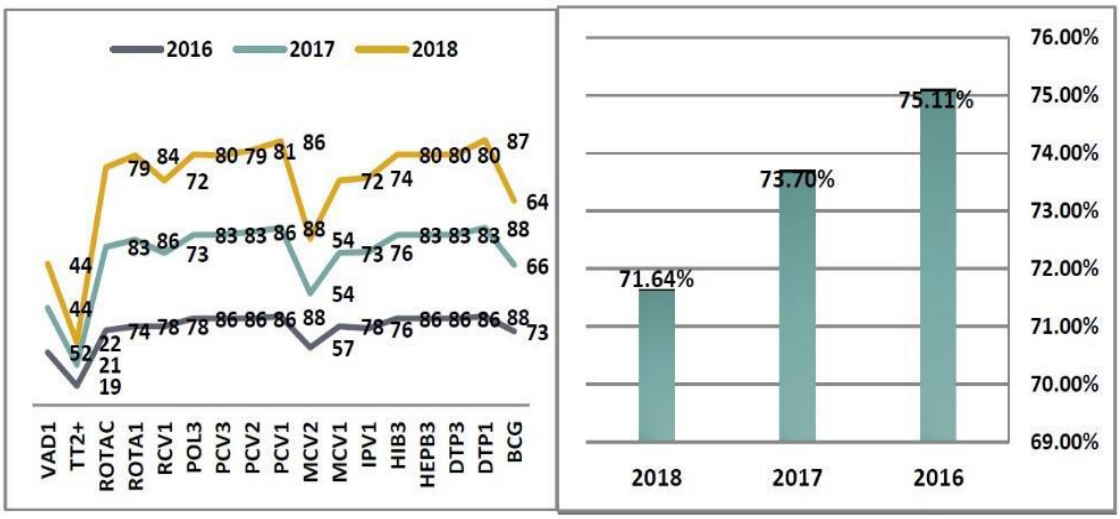


Figure 14. Children's Vaccination coverage in Yemen from 2016 to 2018 (52)

In 2019, Yemen's Expanded Programme on Immunization (EPI) took proactive measures to safeguard children under the age of one from severe illnesses like diphtheria, cholera, and polio (51). They accomplished this through routine immunization efforts and targeted vaccination campaigns. Notably, over 82% of children in this age group received various EPI vaccines during that year. Overall, over 50 million doses of different vaccines, were administered in 2019 through the EPI, thereby achieving an average coverage of 80% of the target group, during the conducted campaigns, which is still below 90%, the recommended rate by the WHO. Despite the civil war, the WHO in collaboration with local authorities in both parts of the country, has continued vaccination campaigns through integrated outreach activities (51).

3.1.2 WASH

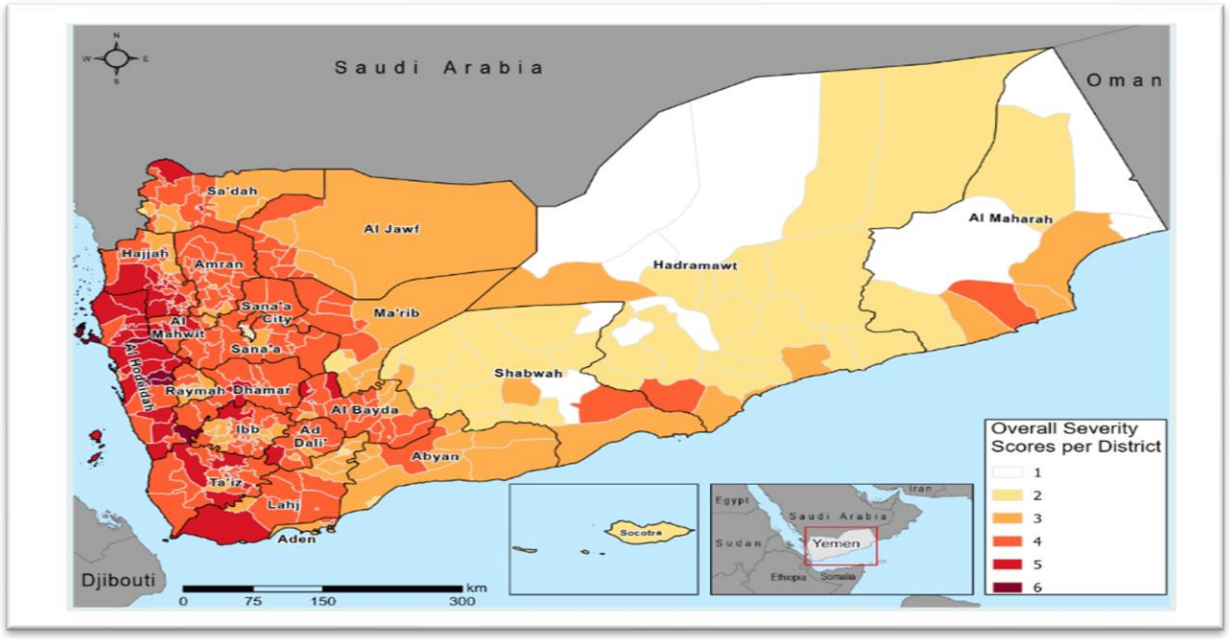
In May 2003, Yemen established the Ministry of Water and Environment (MWE) with the primary goal of restructuring the water sector, implementing integrated water resources management, and creating the required institutional and investment framework to address the escalating water challenges in Yemen. Under the management of MWE, numerous agencies of water have been developed, such as National Water Resource Authority (NWRA), Local Corporations (LCs), General Authority for Rural Water Supply Projects (GARWSP), and Local Water and Sanitation Company (LWSC) (53).

The civil war in Yemen has had a detrimental impact on access to WASH services, increasing vulnerability to communicable diseases. The prolonged crisis has resulted in millions of water-, sanitation-, maintenance-, and health workers being deprived of regular salaries, leading to severe cuts in essential services (34). This war has exacerbated the situation, imposing additional constraints on the effective provision of safe water in both urban and rural regions of the country (54). In 2022, an estimated 17.8 million individuals, representing 58% of the total population, needed assistance to fulfil their basic WASH requirements, marking a 16% rise compared to 2021. The number of people facing acute WASH needs has escalated by 28.7%, from 8.7 million to 11.2 million individuals in 2022 (30).

In Yemen, the WASH cluster, under the leadership of UNICEF, faces a critical challenge as 70% of health facilities lack reliable water sources. These facilities rely on irregular water trucking or limited water supply services, available for less than five days a week. A staggering 61% of health facilities suffer from inadequate sanitation facilities (55). The situation is particularly dire for vulnerable groups, such as children under 5 (CU5) and women, who endure higher risks regarding their access to sanitation and water. Statistics show that they are three times more likely to resort to defecating outdoors, face four times limited accessibility to sanitation facilities, and endure an eight-fold scarcity of clean drinking water. Infections resulting from compromised water quality and inadequate sanitation pose a significant threat, with CU5 being over 20 times more likely to succumb to such diseases compared to physical assaults (56).

Conducting an extensive systematic review and meta-analysis, this study delved into the interplay between WASH exposures and cholera. The comprehensive analysis encompassed 51 case-control studies from 30 different countries (57). The results highlighted a noteworthy correlation, as all eight predicted risk factors demonstrated a substantial association with an elevated likelihood of cholera, showing odds ratios spanning from (OR=1.9 to 5.6). Notably, some variability was observed, evident from the heterogeneity values spanning an I^2 of (0.0% to 91.8%). Among the identified risk factors, improved hygiene practices emerged as a potent factor in diminishing the odds of cholera, displaying an (OR=0.34) in cases of observed good hygiene. Conversely, open defecation stood out as a paramount contributor to an increased susceptibility to cholera, displaying an (OR=5.6) (57).

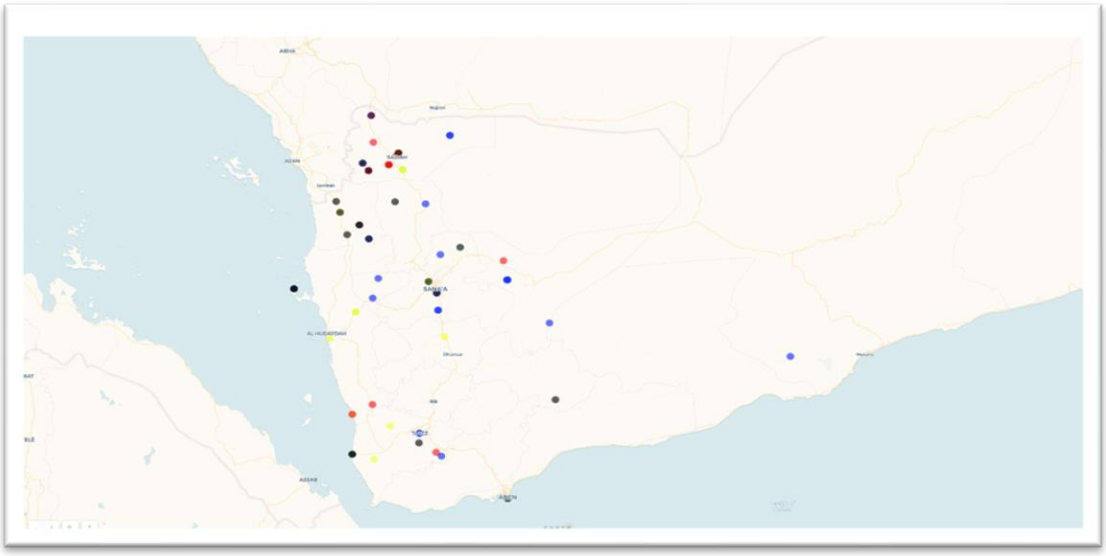
In 2020, a significant proportion of districts in Yemen, precisely 97% (323 out of 333), were identified as having Moderate or Acute WASH needs, based on desk review for 117 WASH reports (20). These districts were assigned Overall Severity Scores ranging from two to six (Map 4). Among these districts, 63% (209 out of 333) were identified as having Acute Needs, while 114 districts (34%) were categorized as having Moderate Needs. Notably, this represents a slight improvement compared to the previous year when all districts were classified as being in Moderate or Acute need. The number of districts in Acute Need decreased by 33, going from 242 to 209, while the number of districts in Moderate Need increased by 23, rising from 91 to 114 (20).



Map 4. Overall WASH Severity Scores (20)

A range of infectious diseases including vector-borne and water-borne illnesses, have affected Yemen during the latest conflict, including malaria, dengue fever, chikungunya, AWD, and cholera (58). Following the capital city, Sana'a, the incidence of a cholera outbreak, in Al Hodeidah governorate has taken second place, as 655 suspected cases/1000 persons have been reported. The utilization of insufficient and unimproved water sources was the contributing risk factor for cholera development. Other factors linked to an elevated risk of water-borne diseases like cholera include poor hand hygiene, limited access to clean and functional latrines, and the presence of wastewater or sewage near residential areas (58).

Throughout 2019, 176 incidents of damage to critical infrastructure were reported, with Al Hodeidah governorate being the most affected, accounting for 70 incidents, primarily occurring in Al Hali and Al Hawak districts. Out of these incidents, 12 were related to WASH infrastructure, down from 31 reported in 2018 (59). Map 5 shows WASH infrastructure locations targeted by airstrikes during the period from April 2015 to December 2017. Additionally, in 2019, there was a decrease in damage to critical infrastructure compared to 2018. There was a 17% increase in reported damage to civilian houses, with 6,839 incidents recorded throughout the year. Damaged homes pose a higher risk of reduced access to water supply networks, potentially leading to increased WASH needs for the inhabitants (60).



Map 5. Locations of airstrikes targeting water infrastructure, April 2015-December 2017 (61)

The conflict has exacerbated the cholera outbreak in Yemen especially in the northern governorates. In districts with active war activities, there is a significant water scarcity issue and extreme WASH needs. These districts are primarily located in the remote governorates of Al Jawf, Al Bayda, Al Hodeidah, Hajjah, Marib, Shabwah, and Taiz. Within these districts, approximately 5.3 million individuals, including 2.6 IDPs, are facing acute WASH needs. Based on data from Health Cluster surveillance, over 10,000 suspected cases of AWD were reported in 32 districts, accounting for 43% of the total suspected cases in 2021. The Multi-Cluster Initial Rapid Assessment findings also revealed inadequate water treatment practices, as 64% of respondents reported a lack of chlorine tablets, and 19% expressed uncertainty regarding water treatment methods (30).

3.1.3 Education and Lack of Awareness

The latest conflict in Yemen has seriously impacted the education status, leading to a significant decline in the literacy rate among individuals aged 15 and above. The literacy rate stands at 21.3% in 2018, compared to the situation in 2016 with 22.5% (Figure 15) (52). This deteriorated literacy rate can be attributed to many factors, prominently the consequences of the recent war and the struggling economy. These obstacles have intensified the situation of the education section, leading to delays, reductions, or even cancellations of initiatives aimed at promoting education (52).

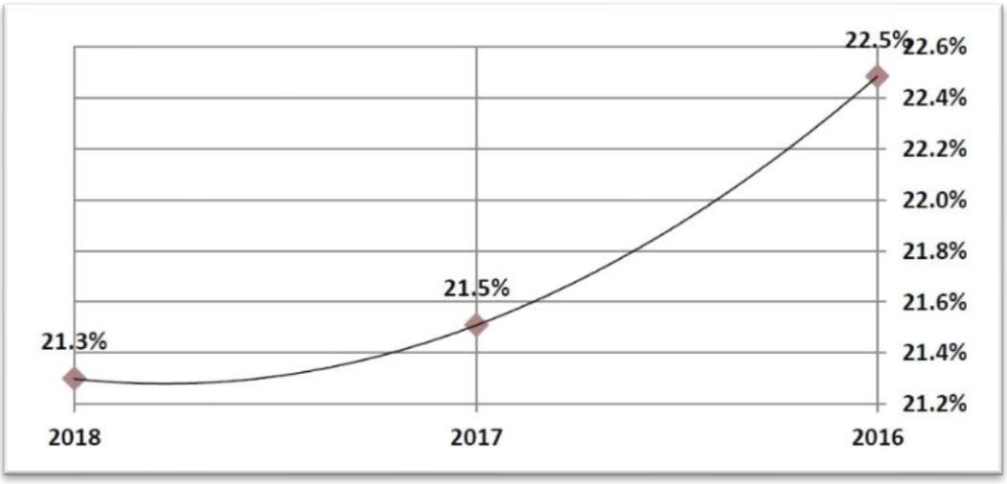


Figure 15. Literacy rate in Yemen during the period from 2016 to 2018 (52)

Not only literacy rate has been affected by the civil war, but also the enrolment of students aged 15-18 years old has been adversely affected. For this group, the enrolment rate reaches 25% in 2018 compared to its rate stands at 31% in 2016 (52). Even the enrolment of students aged 19-24 years old, at the university level, has been affected and went down showing 7% in 2018 compared to the 9% and 8% in 2016 and 2017, respectively (Figure 16). This sustained reduction signifies an ongoing trend of decreasing university enrolment. The prolonged civil war has disrupted education systems, creating an environment of insecurity that discourages students from pursuing higher education. The country's economic challenges exacerbate the situation, making it difficult for families to afford the costs of attending universities. Additionally, deep-rooted gender disparities limit access to education for many girls and women, further contributing to the enrolment decline (52).

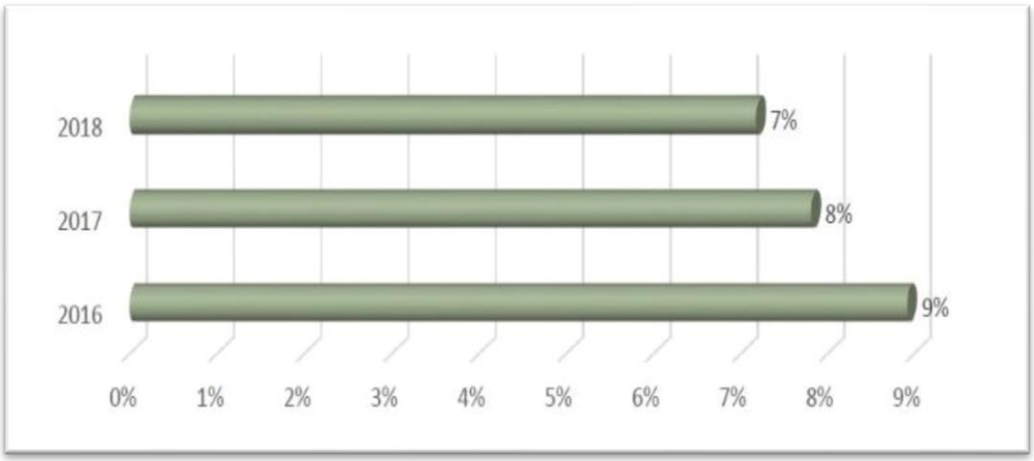


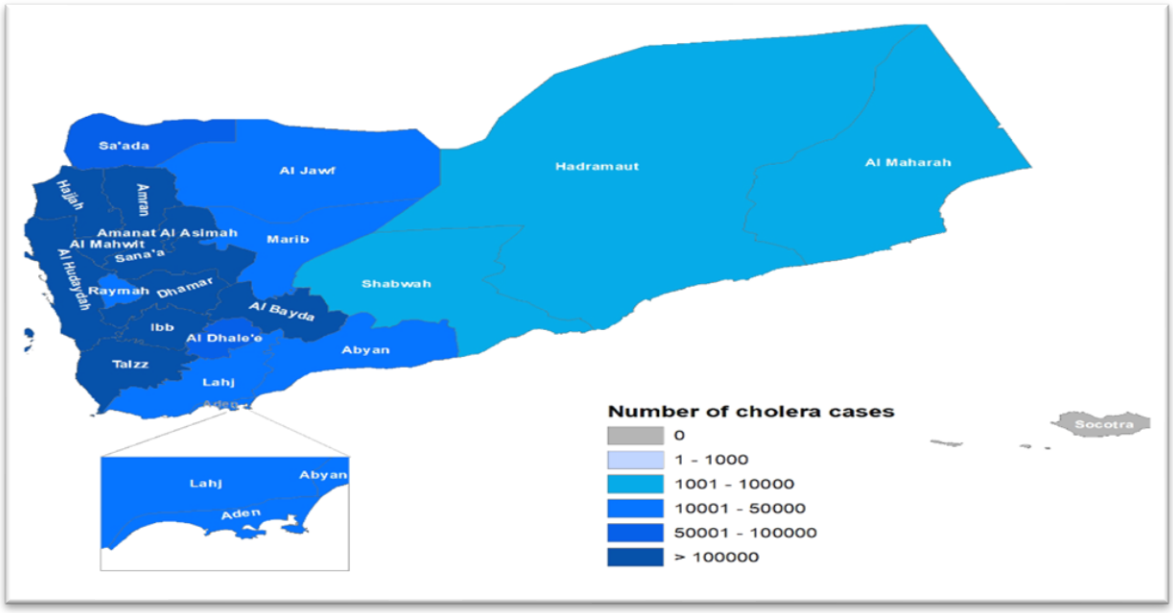
Figure 16. Rate of university enrolment during the period from 2016 to 2018 in Yemen (52)

No more articles or data were found to have an association between Education level and cholera occurrence either in Yemen or any other LMICs.

3.1.4 Residency

When WHO's most recent epidemiological data on cholera for the period of April 27 to July 31, 2017, is analysed together with data from Risk Intelligence, which indicates areas of the internationally recognized government (IRG) and De facto Authorities (DFA) under Houthis control, a clear pattern emerges (62). It appears that the cholera outbreak disproportionately impacts areas under DFA authority. Specifically, 67.1% of Yemen's population resides in IRG-controlled regions, either wholly or predominantly, while 22.7% live in governorates controlled by the IRG government. The remaining population resides in Taiz governorate, with significant parts under the control of both conflicted parties (62,63).

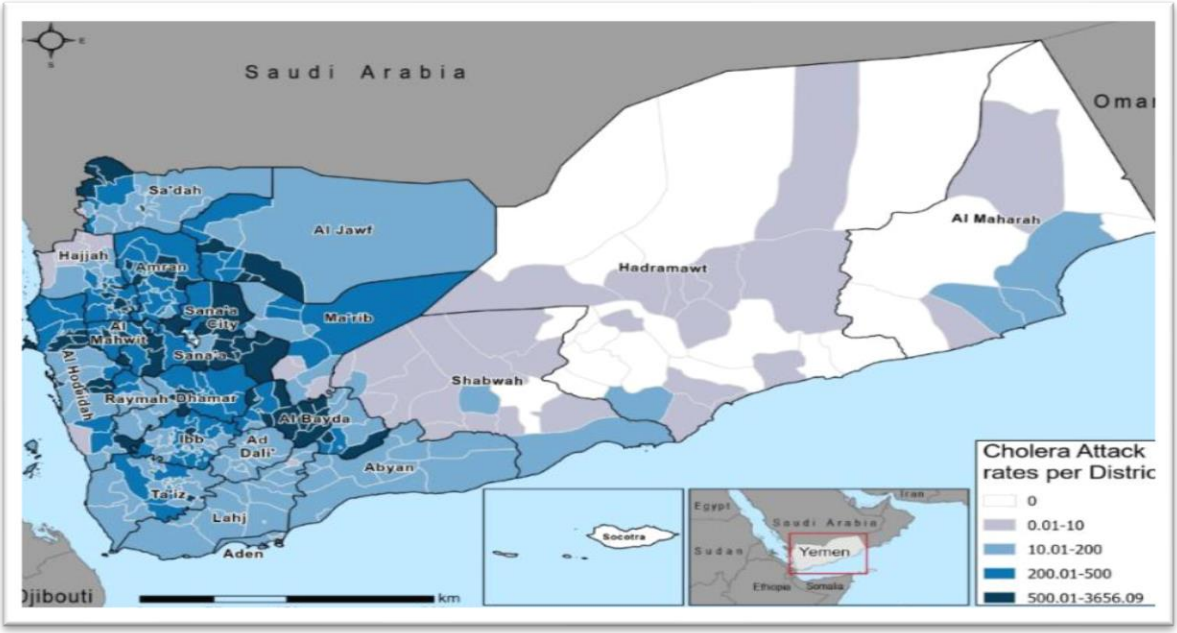
During the same time, in the northern governorates, the analysis of provided data has revealed that 77.7% of reported cases (339,061 out of 436,625) and 80.7% of deaths (1545 out of 1915) occurred in these regions (62). In contrast, fewer cases were reported from the southern governorates (15.4%) and deaths (10.4%). The northern governorates led by DFA showed higher attacks rate which stands at 17.0 per 1000 compared to 10.0 per 1000 in southern cities under IRG authorities. The case–fatality rate, which indicates the percentage of deaths among the reported cases, was 0.46% in DFA-controlled areas and 0.30% in IRG-controlled areas (62). Map 6 shows the distribution of suspected cholera cases in the northern and southern Yemen governorates.



Map 6. Distribution of suspected cholera cases in Yemen, 27 April 2017 - 30 April 2021 (64)

The governorates most severely impacted by the outbreak were Amanat Al Asima, Al Hodeidah, Hajjah, Amran, and Dhamar, collectively accounting for 53% (231,228 out of 436,625) of the reported cases since 27th April 2017. The highest attack rates were observed in Al Mahweet, Al Dhale'e, and Amran governorates, with rates of 33.9%, 33.0%, and 29.1%, respectively. Regarding case fatality ratios, Raymah, Hajjah, and Ibb governorates reported the highest percentages, standing at 1.2%, 0.8%, and 0.7%, respectively (62). Map 7 shows the cholera attack rate

distribution in Yemen governorates. It was highlighted that the civil war, which commenced in 2015, was behind the cholera outbreak's endemicity in both parts of the country, based on a statement issued by UNICEF and WHO in late June 2017. The statement refrains from singling out any party as more responsible than the other. Instead, it emphasizes that the prolonged conflict, lasting for two years, has severely damaged the health, water, and sanitation systems in Yemen, leading to the current crisis (31).



Map 7. Cholera attack rate distribution in Yemen governorates (58)

3.1.5 Socio-economic

The ongoing conflict in Yemen has intensified the already deteriorated and unstable socioeconomic situation. The country entered a highly destructive phase starting in 2014, which further intensified from 2015 onward, after the civil war (65). Before the conflict, Yemen has been considered one of the most impoverished states globally, showing the lowest human development indicators in the Middle East and North Africa region (MENA) (66). Despite that Yemen's economy has been relying on oil for a long time, the latest war has affected the oil industry resulting in a significant reduction in oil revenues and looking for another alternative resource. The Yemeni authorities have struggled to find solutions in non-oil industries such as gas, agriculture, fisheries, manufacturing, and financial services (67).

The poverty line in Yemen set at 278.8 Yemeni rials (2014) or US$1.90 (2011 PPP) per day per capita, indicates the minimum income required to meet basic living standards and highlights the challenging economic conditions faced by a significant portion of the population in the country, according to World Bank (68). The Yemeni government's GDP, standing at $1,118 per capita, holds the unfortunate distinction of being the lowest in the Middle East region. This has seen a

drastic drop of nearly 50% of GDP due to the recent civil war. This has exacerbated the poverty rate faced by the Yemeni population, which has now risen to 58%. This alarming rate is significantly higher than the pre-war poverty rate of 19%. Currently, approximately 80% of the population still requires humanitarian support, underscoring the pressing and ongoing need for assistance in Yemen (69). The conflict has imposed economic losses on 100,000 individuals destructing their livelihoods, while various factors including fragile infrastructure, limited health services, and food insecurity have led to an estimated 130,000 deaths, among them 3000 affected children. Malnutrition was behind the life losses of nearly 45% of the children (69).

According to the World Bank, the unemployment rate pertains to the proportion of the economically active population, who are currently not employed and actively seeking jobs. This rate does not take into account economically inactive individuals, such as the long-term unemployed, children, or retirees (70). In Yemen, unemployment rates are disturbing: 33% and 44% of men and women were 'unemployed' in 2016. In the subsequent two years 2017-2018, the unemployment rate for males stands at 31.9% and 29.9% while for females, it stands at 43% and 41%. (Figure 17) shows the unemployment rates from 2014 to 2018. The latest civil war in 2015 led to significant job losses, resulting in a higher unemployment rate in 2016 compared to 2014. Notably, gender inequality is observed in Yemen with a low unemployment rate for women compared to men. This inequality can be attributed to factors such as lower levels of education among women and societal pressures that limit their employment opportunities in terms of location and working hours (71).

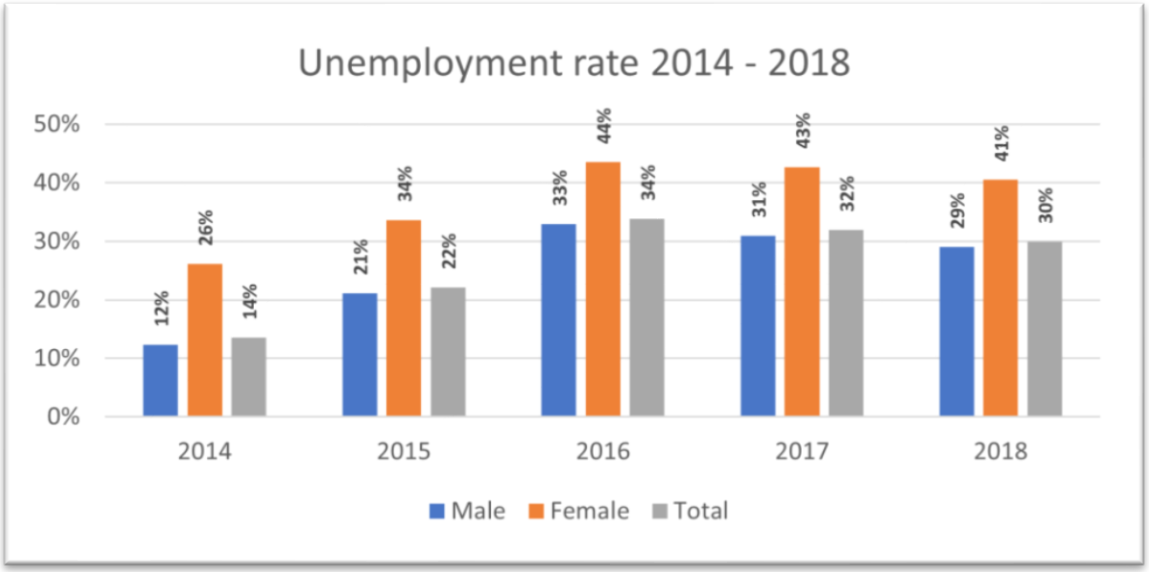


Figure 17. The unemployment rate in Yemen 2014-2018 (71)

It is understood that data on unemployment are always difficult to interpret, especially in a country such as Yemen with an economy dominated by informal labour.

3.1.6 Khat Chewing, Human Behaviours and Gender

Khat (Catha edulis) is a flowering plant found in the Horn of Africa and Yemen. It contains a substance that has similar features to amphetamine, which can lead to some symptoms such as excitement, lack of appetite, and euphoria feeling (72). In Yemen, khat is socially accepted and widely consumed, with most of the population regularly chewing its green leaves for their cognitive stimulant effects. The consumption rate of Khat in Yemen is high at 90% compared to Ethiopia with only 15% (73). A study conducted in Yemen revealed that daily chewing Khat is a common practice, and there has been a conception that insufficient washing of Khat leaves before consumption could be considered a potential risk factor to develop cholera disease (74). Another study revealed that the practice of not washing khat before chewing was associated with cholera in a statistically significant manner [OR, 0.14; 95% CI, (0.05 to 0.46)] (74).

Many risk factors are associated with cholera incidence, according to a study conducted in the capital city, Sana'a. These factors include a history of visitors going and back to the capital, frequent food-taking outside homes, lack of cleaned fruits, vegetables, and khat (a local herbal stimulant) before administration, reliance on shared water sources, and lack of the use of chlorine or soap in household sanitation practices (75). In a systematic study and meta-analysis investigating the risk factors contributing to cholera outbreaks in Africa, one of the identified factors was the consumption of raw vegetables, ranking second in significance. This specific risk factor was addressed in four separate reports. The pooled odds ratio calculation revealed [OR = 1.92; 95% CI: (0.88 - 2.97)]. This indicates that the probability of experiencing a cholera outbreak was nearly two times higher among individuals who regularly consumed raw vegetables (76).

For decades, Yemen has been plagued by deeply rooted gender disparities, perpetuating the prolonged suffering of women and girls who face neglect and discrimination. The ongoing civil war has exacerbated this already dire situation. For consecutive years, the Global Gender Gap Index ranked Yemen among the lowest countries. As a result of gender issues in Yemen, an estimation of 2.2 million Yemeni women and girls of reproductive age, face serious risks to their well-being and safety, while approximately 500,000 pregnant women encounter challenges in accessing WASH services and obtaining safe and affordable medical care. The convergence of the ongoing conflict and deeply ingrained gender norms have compounded the issue, imposing additional limitations on the mobility of women and girls and creating significant barriers to accessing essential services, thereby increasing their vulnerability to cholera outbreaks (77).

3.2 Aggravating factors

3.2.1 Displacement and Overcrowding

According to the Internal Displacement Monitoring Centre (IDMC), more than 4 million IDPs have been reported in Yemen as of December 31, 2022. Figure 18 reveals the updated number of IDPs till the end of 2022 (78). This number entails not only IDPs from the previous year but also those who have been internally displaced several years ago. In 2021, the conflict has internally displaced around 377,000 individuals in Yemen, while natural disasters, primarily heavy rains, and floods, have displaced approximately 84,000 people (78). In densely populated regions, the availability and accessibility of essential health services are restricted, and meeting other basic

needs, like access to clean water, also becomes challenging. The available WASH infrastructure and health services could be fragile even before the emergence of cholera outbreaks in such places (30).

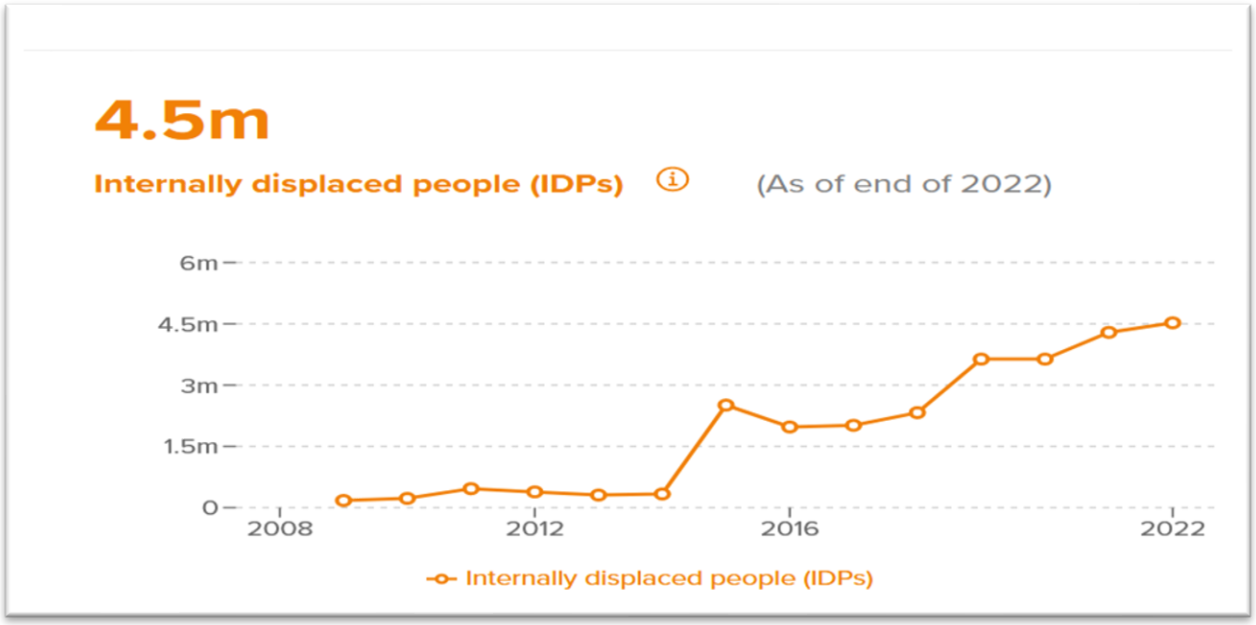


Figure 18. IDPs as the end of 2022 (78)

In 2020, Yemen experienced an escalation of the protracted civil war, exacerbated by climate change matters. Vulnerable communities have been affected by flooding which has accelerated the transmission of communicable diseases including cholera (30). Over 300,000 IDPs, who have been displaced due to the conflict, were adversely affected and decided to displace for the second time to alternative safe places (79). According to monitoring data from the cluster of Camp Coordination and Camp Management (CCCM), approximately 15.3% of informal sites (makeshift settlements where IDPs temporarily reside without proper infrastructure) hosting IDPs rely on unprotected water sources such as surface water, wells, rainwater, etc. Additionally, 28% of these sites depend on water trucking for their water supply, while 52% lack access to improved sanitation facilities which has intensified the cholera outbreak (30). Figure 19 illustrates the top five governorates that hosted the highest number of IDP households in 2019. These numbers encompass both IDP households residing in informal settlements and those living within host communities (Local populations providing shelter and support to internally displaced persons in their areas).

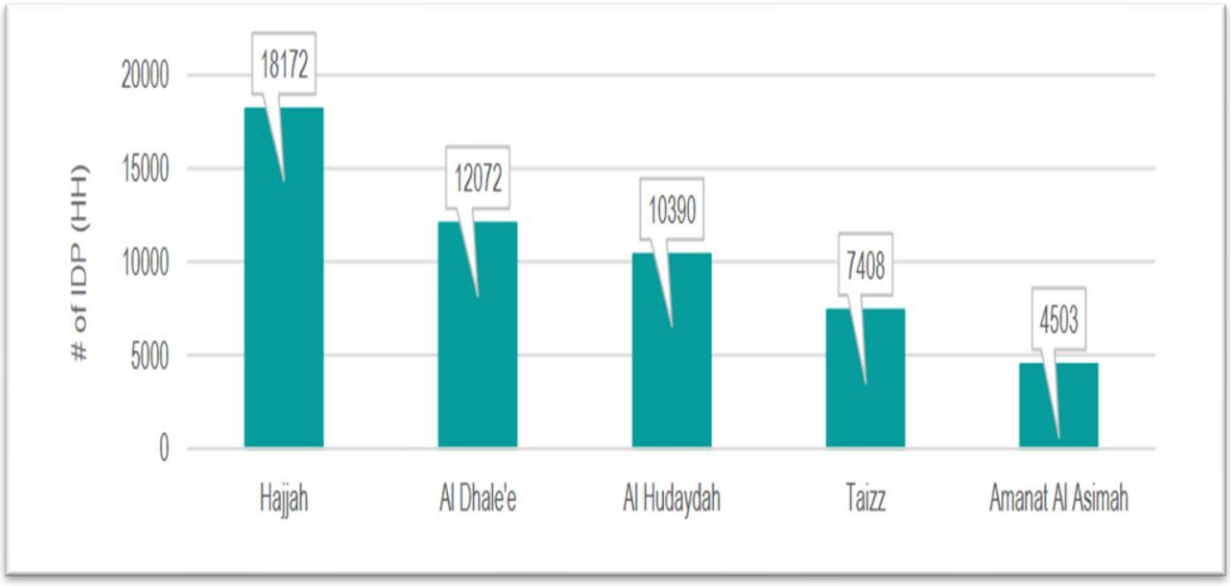
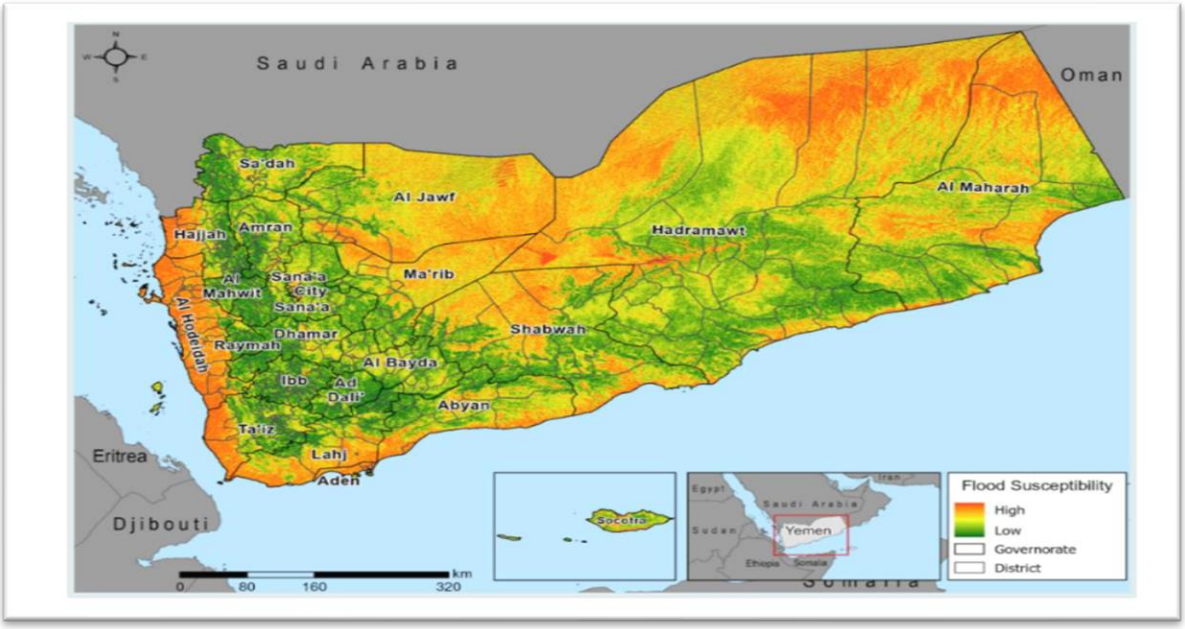


Figure 19. Total of # IDP households in 2019 by top 5 governorates (58)

The continuous arrival of refugees from Africa has exacerbated the precarious situation in Yemen (20). There is a persistent flow of migrants from East African countries seeking safety and a secure pathway to Gulf nations, with Saudi Arabia being a significant destination. In 2019, the International Organization for Migration (IOM) reported that over 138,000 African individuals migrated to Yemen. The accumulation of IDP numbers alongside the ongoing migrants from Africa, puts immense pressure on already limited resources, including WASH facilities and access to clean drinking water. As a result, there is a growing strain on the available resources, leading to the exacerbation of the cholera outbreak (20).

3.2.2 Climate change

The deteriorated humanitarian situation in Yemen has been exacerbated by the changes in climate. Various challenges of climate change such as drought, frequent flooding, pest infestations, seasonal infectious diseases, heavy rainfalls, intensified and more frequent storms, as well as rising sea levels, have ensured an exceptional impact on Yemen's conditions (80). Flash flood disasters have affected over 28,000 individuals leading to the transmission of infectious diseases such as cholera and malaria in 2021. Map 8 shows the susceptibility of Yemen to floods. Following the onset of the rainy season, the lack of clean water has contributed to the increase of cholera cases alongside bacteria proliferation (81). Recognizing the significance of high-risk factors, particular attention has been directed towards mitigating their impact in critical contexts like untreated water resources, agriculture systems, and coastal areas, with a particular focus on the southern region of the country (82).



Map 8. Yemen Flood Susceptibility (59)

Yemen's climate can be characterized as a subtropical dry and hot desert climate, with low annual rainfall. The country experiences extremely high temperatures during the summer and notable temperature variations between the maximum and minimum, particularly in the inland regions (80). Global climate change may already be influencing the occurrence of diarrheal diseases by altering temperature patterns. In LMICs, a comprehensive systematic review and meta-analysis were conducted, analysing 26 studies. The research aimed to investigate the correlation between ambient temperature and two types of diarrhoea: all-cause diarrhoea and bacterial diarrhoea. The findings revealed a significant positive association between elevated temperatures and both all-cause diarrhoea (Incidence Rate Ratio - IRR 1.07; 95% CI 1.03, 1.10) and bacterial diarrhoea (IRR 1.07; 95% CI 1.04, 1.10), indicating a higher incidence of these diseases during hotter periods (83). Although the correlation is considerable, this infers that elevated temperatures are connected to a minor elevation in the likelihood of contracting diarrhoea due to bacterial pathogens.

The WASH facilities in Yemen's northern and southern regions have experienced adverse impacts from climate change. The country typically receives regular rainfall twice a year during the winter and summer seasons. These precipitation patterns have been disrupted due to climate change-related factors (20). As a result of these rains, floods and flash floods affect the country particularly lower-elevation areas such as plains, and deserts. In previous times, these floods used to be exploited by farmers for irrigation purposes (59). The damage resulting from floods has been intensified by desertification. Concerning WASH, these floods hurt related infrastructure, resulting in damage. They contribute to the higher transmission of infectious diseases like cholera, malaria, and dengue fever (84).

3.2.3 Malnutrition

In 2019, Yemen's food security situation was dire, evident from its ranking of 116th out of 117 countries on the Global Hunger Index. Even before the outbreak of the civil war in 2015, Yemen already held the unfortunate distinction of being the most impoverished country in the Arab world, with a national rate of Global Acute Malnutrition (GAM) reaching 12.7% as of August 2014 (85). GAM holds a pivotal role as a metric for assessing the nutritional well-being of populations, particularly in times of humanitarian crises and emergencies. It gauges the occurrence of acute malnutrition within a community, typically expressed as the proportion of children affected by either moderate acute malnutrition (MAM) or severe acute malnutrition (SAM). This indicator plays a vital role in understanding and responding to the nutritional needs of vulnerable communities during crises (86). Based on the WHO, the child malnutrition situation has observed deterioration during the first half of 2022, as compared to previous years. The GAM rate surged to 27% in 2022, significantly higher than the average rate of 23% seen in previous years (87). Despite efforts conducted by humanitarian partners, particularly WFP, the GAM still showed alarming rates in most Yemeni districts (20).

Poor WASH conditions have been identified as the most crucial contributing factors to observed GAM rates. The utilization of unimproved water sources significantly correlates with higher GAM rates among CU5 due to an increased risk of AWD. Moreover, inadequate hand hygiene practices before eating and after using the restroom, along with overall personal hygiene, have a strong association with elevated rates of malnutrition (20). Due to the challenging economic situation and high inflation rate, Yemeni families have resorted to coping mechanisms such as borrowing food, adjusting the quality and quantity of their meals, and even sending their children to live with relatives. These actions are taken in response to the family's limited food income and the need to adapt to difficult circumstances (88).

During the year 2020, a severe occurrence of acute malnutrition happened among approximately 50% of CU5 and around one million PLWs. Among these affected children, approximately 400,000 CU5 were affected by SAM (30). In the year 2021, Yemen faced a significant national health challenge with the persistence of acute malnutrition, including SAM and MAM (Figures 20 & 21). Looking ahead to 2022, projections indicated that around 2.2 million children would continue to be affected by acute malnutrition, with an estimated 538,000 CU5 suffering from SAM. Additionally, around 1.3 million PLWs would continue to suffer from MAM in 2022 (89). Approximately 316,846 children under the age of one are now vulnerable to illness and death due to malnutrition-related risks. Additionally, the stunting rate has reached 48%, posing a threat to the long-term health and well-being of approximately 2,816,410 infants, who may face lifelong effects if they experience stunting (87).

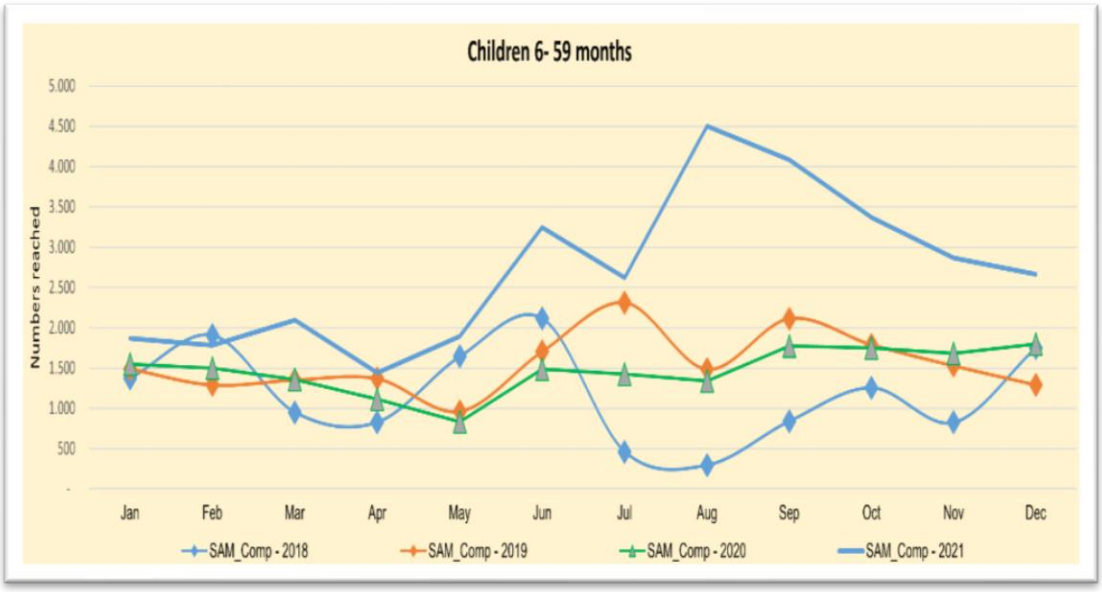


Figure 20. SAM in CU5 during 2018 - 2021 in Yemen (90)

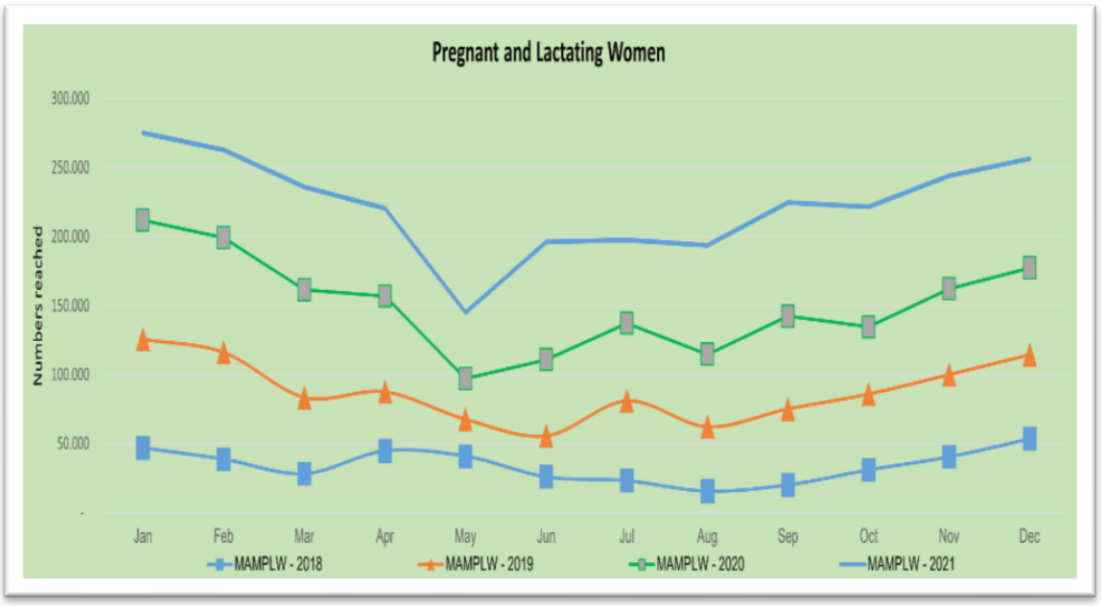


Figure 21. MAM in PLWs during 2018 - 2021 in Yemen (90)

Yemen experiences significant levels of food insecurity and malnutrition, which intensify people's vulnerability and susceptibility to cholera disease. Cholera particularly affects governorates with high food insecurity, exacerbating the situation in those regions (91). There has been an observed overlap between cholera outbreaks and urgent food and nutrition requirements in 67 districts of Yemen (92). By March 2017, in four governorates of Yemen (Taiz, Abyan, Al Hodeidah, and Hadramout), the threshold of GAM rate has shown an alarming result with 15% above the standard threshold of WHO. SAM rates have revealed high levels (91). Figure 22 below illustrates the

presence of overlapping high levels of food insecurity and significant cases of AWD/cholera across various regions of Yemen, including coastal, central, and mountainous areas.

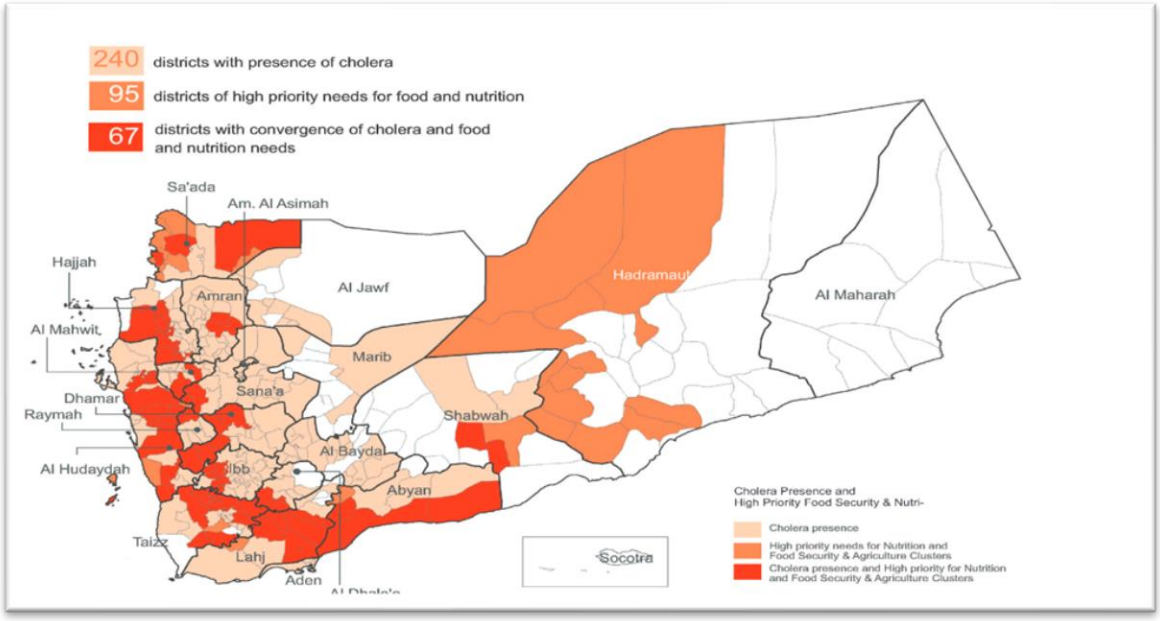


Figure 22. Convergence of food insecurity and cholera in Yemen (91)

3.2.4 Access Limitations for Humanitarian Organizations

The severity of the humanitarian crisis, particularly regarding the AWD/cholera epidemic, presents significant obstacles for numerous humanitarian organizations due to access restrictions. These restrictions materialize through the withholding of field movement permits for national staff, encounters with ad hoc and well-known checkpoints leading to extended vehicle detentions, occurrences of car-jacking, and lengthy visa procedures. These challenges collectively impede the timely deployment of essential cholera and other humanitarian response specialists. INGOs face considerable delays as their cholera specialists and other crucial staff members necessary for emergency response efforts are stranded abroad for more than a month (91).

The IRG in Yemen has recently requested the UN and INGOs to obtain visas through their diplomatic officers. Initially, this requirement applied only to the southern part of the country, while visas for the north were granted in Sana'a. However, starting from 16 August 2017, new visa applications needed to undergo a dual process, it had imposed additional access difficulties on INGOs. On the other hand, the presence of local conflicts in specific regions in Yemen presents additional obstacles. One example is the Harf Sufyan district, located north of the Amran governorate, which houses a significant military camp frequently targeted by airstrikes. Despite an estimated 60,000 individuals, who reportedly face a high number of suspected cholera cases, aid agencies are unable to access the communities due to the militarized nature of the area. As a result, there is a lack of confirmation regarding the actual situation in these communities (91).

Chapter 4: Discussion

4.1 Environmental and Socio-economic Factors

One can argue that the devastating civil war in Yemen has resulted in a fragile health system and disrupted WASH services, which have played a major role in the frequent outbreaks of cholera in the country. The research findings suggest that various factors, including affected eDEWS (early warning systems), poor governance, limited funds, inadequate healthcare workforce, shortage of medical supplies, and deteriorating WASH infrastructure, have collectively contributed to the high incidence of cholera disease in Yemen. Similarly, in Sub-Saharan Africa (SSA), countries with weakened health systems and compromised WASH infrastructures have experienced widespread diarrheal infectious outbreaks. Access to developed WASH services remains limited, with only 53% of the population in SSA having good accessibility to such facilities. Between 2010 and 2015, approximately 200 million people resided in regions where cholera outbreaks were documented (93,94). The consequences were particularly impactful on mortality rates, with 83% of all cholera-related deaths from 2000 to 2015 recorded in SSA, as stated by the WHO (51).

Insufficient funding for the 'Yemen Humanitarian Fund (YHF)', which is led by OCHA and depends on international donors, further worsened the humanitarian situation in Yemen. The country faced a critical shortage of funds, with only $1.4 billion received out of the requested $4.3 billion in 2022 (44). Many factors such as elevated need due to the Russia-Ukraine conflict, rising operating expenses, and reduced funding, resulted in a limitation of the scope and scale of humanitarian interventions in the country.

The findings showed that numerous humanitarian partners, both national and international NGOs, have actively participated in the integrated response to the cholera outbreaks in Yemen. Among UN agencies, the WFP has played a role in addressing escalating food assistance needs, combatting malnutrition, and offering vital logistical and emergency support. UNICEF's commendable efforts in association with MWE in Yemen, in providing access to safe water and sanitation solutions, coupled with their hygiene promotion campaigns, have contributed to alleviating the cholera outbreaks burden. The WHO has played a role in providing support, for both MoPHP in the northern and southern parts of Yemen, in bolstering the health system's capacity for surveillance, case management, and community engagement. Despite the collective endeavours undertaken by humanitarian partners, the underlying determinants of the cholera outbreak persist as deeply entrenched challenges.

As per the findings of this review, an effective blockade, encompassing all imports by de facto authorities, including humanitarian aid, has created substantial challenges in acquiring sufficient OCVs, medical supplies, food, and fuel necessary to address the country's cholera outbreak. Yemen exhibits a favourable immunization coverage indicator at 71.6%, compared to Ethiopia's 38.3%. Both countries still have a considerable distance to go in achieving the WHO's 2030 coverage of 90% (95). Despite efforts made by active humanitarian partners in facilitating the importation of medical supplies and vaccines for the response efforts in Yemen, they faced challenges in meeting the escalating demand promptly. There were instances where the increasing needs outpaced their ability to deliver supplies promptly (96). Since the escalation of the conflict,

Yemen has received only 30% of the medicine supply that was previously entering the country (97).

The findings revealed a significant association between the development of cholera in Yemen with drinking from uncleaned water sources such as wells. In Iran and Nigeria, similar studies have shown the same association between cholera incidence and drinking unsafe water (98,99). It was found that keeping water inside containers without proper treatment led to high contamination of water, resulting in bacterial infections (99). In Yemen, a study showed a three-fold rise in the risk of contracting cholera through stagnant untreated water inside containers without treatment. These findings align with similar ones from previous studies conducted in Vietnam and Tanzania (100,101).

It was observed that destroyed waste management systems together with persistent human behaviours such as defecation in open areas are important contributing factors to the cholera occurrence in Yemen (56). Likewise, in Ghana, an environmental evaluation conducted among the impacted communities has revealed that exposures to inadequate waste management, clogged drainage systems, overflowing garbage sites, and the prevalence of open defecation practices have contributed to the development of cholera within these vulnerable communities (102). Additionally, in South Sudan, it was observed that individuals eating food in restaurants outside their homes and frequently traveling from and to home villages, even within the same region, have shown high vulnerability to developing the cholera disease. The identification of eating outside the home as a risk factor in this cholera outbreak aligns with similar findings from cholera outbreaks in Uganda and Haiti (103,104).

School enrollment and literacy rates have experienced a continuous decline, marked by significant gender disparities. Yemen exhibits a student enrollment rate of 25% among those aged 15-18, which contrasts with the 78% recorded in the Democratic Republic of Congo (DRC) in 2017 (105). As a result, there is insufficient awareness and comprehension of diseases such as cholera, encompassing aspects like its origins, preventive measures, healthcare practices, the importance of children's OCV vaccination, and the management of diarrhoea through ORS treatment. Furthermore, distinctive cultural factors such as the widespread practice of Khat chewing have also played a role in the emergence of cholera.

The review underscores the alarming socio-economic circumstances prevalent in Yemen, marked by surging unemployment rates and an ongoing increase in poverty levels within the populace. By 2019, Yemen witnessed a troubling poverty rate of 75%, surpassing that of the Democratic Republic of Congo, where almost 62% of its inhabitants survived on less than $2.15 daily, as indicated by the World Bank (105). In Yemen, national budgets for health decreased which led to significant problems in terms of availability of health staff, functionality of health facilities, supplies of medicines and OCVs, and so on. Consequently, the decline in financial and geographic accessibility to healthcare services has worsened, possibly playing a role in the emergence of large-scale cholera outbreaks witnessed recently (30).

4.2 Aggravating factors

It can be stated that malnutrition and climate change play the most significant roles as exacerbating factors that contribute to the occurrence and severity of cholera outbreaks in Yemen, particularly among IDPs. The reports and studies consistently demonstrate a significant decline in the nutritional status of individuals in Yemen because of the ongoing war. Similarly, the Integrated Phase Classification (IPC) 2022 report highlights the comparable impact of conflict on the nutrition status of the population in Tigray, Afar, and Amhara zones in Ethiopia. In these areas, approximately 5.5 million people are confronted with high levels of acute food insecurity, while the corresponding figure in Yemen reaches 17.4 million. According to the UNICEF situation report in March 2022, the average GAM rate in Ethiopia stands at 17%, in contrast to Yemen's average GAM rate of 23% (106–108). It was also observed in Bangladesh that the prevalence of diarrhoea infections was higher with patients suffering from acute malnutrition. It was noticed that a lower mid-upper arm circumference (MUAC) could be considered a significant risk factor for bacterial diarrhoea (109).

The findings have shown that the prolonged armed conflict in Yemen was further intensified by severe flooding, leading to substantial devastation in communities and creating favourable conditions for the transmission of cholera outbreaks. In a similar setting of some African states, Liberia experienced a severe cholera epidemic due to the outbreak being triggered by civil war. The accumulation of IDPs in camps with limited access to health services has intensified the situation. A similar scenario unfolded during Sierra Leone's decade-long civil war. Similarly, comparable events occurred in Kenya when IDPs were affected by post-election violence, leading to the emergence of cholera cases (110,111).

In summary, the occurrence of cholera outbreaks in Yemen is significantly influenced by interconnected environmental, socio-economic, and (mostly) civil war-related aggravating factors. The civil war's impact on the already fragile healthcare system and deteriorated WASH infrastructure has significantly hindered the utilization of essential services. The prevailing socio-economic challenges among Yemeni households have heightened their vulnerability to food insecurity and malnutrition, leading to an increased susceptibility to communicable diseases, including cholera. Furthermore, the civil war's impact on internal displacement and the growing climate change issues in Yemen have significantly worsened the endemicity of cholera outbreaks in the country. Accessibility to healthcare services has been affected due to financial barriers, and movement restrictions imposed on humanitarian partners, particularly in northern districts have hindered, amplifying the risks of cholera morbidity and mortality. These factors are further influenced by the destruction of public infrastructure, the political situation, the presence of multiple government representatives, reduced government spending on health, and the communities' reliance on humanitarian aid.

4.3 Study Strengths and Limitations

Strengths: This study is the first endeavour to analyse comprehensively the factors influencing cholera outbreaks in Yemen amidst an ongoing conflict, based on the author’s knowledge. The author has discussed and analysed the contributing factors including environmental, socio-economic, and aggravating factors which have contributed to the cholera outbreaks. A proper

analytical framework has been adjusted to ensure a thorough examination of these factors, and helped the author to cover all highlighted factors, shedding light on existing gaps and offering valuable insights for strengthening the health information system and guiding future research and interventions.

Limitations: As a result of the ongoing war since 2015, there is a scarcity of updated data on the subject. The available data is primarily taken from annual reports of MoPHP, national and international NGOs. Reports from OCHA such as the Humanitarian Needs Overview (HNO) and Yemen Humanitarian Response Plan (YHRP) have been used. Additionally, reports from the World Bank, WFP, WHO, and UNICEF have also been pursued to enrich the thesis as well. Nevertheless, it is important to note that reported data is still prone to biases. The latest updated data obtained from the Yemeni government was YDHS which has been conducted in 2013. The articles and resources about cholera outbreaks during the war are also limited, with studies facing constraints in terms of data availability. Many of the recent articles analyse data from the YDHS 2013, which is beyond the scope of this study due to the changes in demographics and the country context since 2015.

Chapter 5: Conclusions and Recommendations

In short, the findings of this descriptive literature review on the dynamics of the cholera situation in Yemen can be summarized as follows:

1. In Yemen, cholera is an *endemic* disease with a *considerable incidence rate of cases*, when compared to other relevant countries. Regularly, there are important outbreaks. This review showed some evidence for specific determinants, e.g., crowding (e.g., in camps for IDPs and areas where WASH conditions are worse than average (e.g., in some Districts in the north of the country under the current DFA government).
2. *Even before* the onset of the civil war, the *conditions were not quite favourable* to prevent cholera. Adequate coverage (geographical and financial access, quality of care) of health services has been quite poor. Further, WASH conditions for the population were poor as well. School enrolment rates and literacy rates have been low and steadily deteriorated, with strong gender disbalances. This contributed to limited knowledge about diseases such as cholera (origin, modes of prevention, health behaviour, the need to vaccinate children with OCV, diarrheal treatment with ORS, etc.). Specific cultural issues, such as Khat chewing, have also contributed to cholera development.
3. The *civil war has most probably accelerated* the cholera outbreaks. Admittedly, existing statistics on cholera, including statistics on trends of cholera incidence e.g., by District, are grossly lacking; hence, the justification for this thesis is to look at the cholera problem in a holistic manner. This thesis examined various consequences of the continuing conflict that may further explain the continuing and perhaps even growing cholera problem. Due to the existence of two distinct Ministries of Health, comprehensive cholera prevention plans are absent. This organizational and institutional fragmentation also led to weaker national supply management systems of essential goods (e.g., of oral cholera vaccine – OCV). The war also led to an increase in IDPs; together with increased migration from East Africa, overcrowding in some areas became quite problematic with cholera as a result. Also, in some Districts, the WASH infrastructure badly deteriorated, with cholera again as a result. Malnutrition rates deteriorated over time; there is evidence that malnutrition is also a determinant of cholera outbreaks. While Yemen was already a poor LMIC country before the war, during the civil war the poverty levels increased – this may also have contributed to the cholera problem.
4. Apart from the effects of the continuing civil war, there has been a *disturbing gap* between requested *funding for humanitarian aid (including health)* and donor pledges. Since Yemen heavily relies on international humanitarian and other aid (e.g., structural aid for health system development), this is a constraint for strengthening basic health services in the country. Also, the implementation of WASH programmes (important as one of the instruments to prevent further development of cholera) is hampered, as is the implementation of other programmes that can be instrumental in the struggle against diarrheal disease and cholera, such as nutrition programmes.
5. *Climate change* cannot be ignored when discussing the development of cholera in recent years. On top of existing and worsening WASH issues, there are more and more droughts coupled with more intensive rainfall.

Following these key findings, the key recommendations to the main stakeholders in humanitarian

aid and health sector development are:

- **For Local Authorities (LAs) in South and North:**

1. To the conflicting LAs and the Saudi-led coalition: To uphold humanitarian law and principles rigorously. This commitment is essential to facilitate the accessibility of humanitarian partners to ensure the safe and effective delivery of aid during cholera outbreaks in conflict-affected areas.
2. For MoPHP in both LAs, in collaboration with WHO: To invest in strengthening the weakened health system, including nurturing studies and continuous research, enhancing surveillance and early warning systems to effectively monitor and control cholera outbreaks.
3. For MWE in both LAs, in collaboration with UNICEF: to invest in improving accessibility to clean water sources, and sanitation facilities, and promoting hygiene practices to prevent the spread of cholera. This includes repairing and building WASH infrastructure in affected areas, implementing proper waste management systems, and promoting hygiene education.

- **For OCHA:**

4. To actively engage in resource mobilization efforts, reaching out to international donors and advocating for increased financial support to fill funding gaps faced by Yemen Humanitarian Fund (YHF). OCHA should enhance the implementation of humanitarian programs and interventions through humanitarian organizations that have a track record of efficiently delivering aid and implementing life-saving programs including cholera prevention and control programs.

- **For Cholera Task Force:**

5. To prioritize the development and dissemination of clear and comprehensive evidence-based guidance tools related to cholera prevention, management, and response. These guidance tools should be designed to cater to various stakeholders, including health workers, local authorities, NGOs, and the public.

- **For WFP:**

6. To further enhance its efforts in tackling food insecurity and malnutrition in Yemen; WFP, in collaboration with LAs and humanitarian partners, should continue its delivery of a comprehensive food assistance package to meet the enormous food insecurity needs in the country through life-saving food programs, expand and strengthen its nutrition activities to effectively prevent and treat malnutrition, with a particular focus on improving children's food intake and increasing school attendance through school feeding programs. Additionally, WFP should prioritize investing in logistics, emergency telecommunications, air transport, and on-demand bilateral services to support the wider humanitarian community effectively.

- **For WHO:**

7. To continue providing comprehensive training on cholera case management and infection control to health workers employed by NGOs and local health authorities. This training should be extended to health workers from both southern and northern governorates, ensuring that all regions are equipped with the necessary knowledge and skills to effectively combat cholera outbreaks.
8. To prioritize the timely provision of necessary supplies to diarrhoea treatment centres and oral rehydration therapy corners. Ensuring an adequate and consistent supply of intravenous fluids,

beds with cleaning materials, and comprehensive treatment kits is crucial to support health facilities and frontline workers in providing effective care.

- **For UNICEF:**

9. To actively promote integrated response approaches that combine improving WASH services and the use of OCVs to address the root causes and transmission pathways of cholera. To maximize the success of this integrated approach, UNICEF should engage with local communities and authorities to raise awareness about the importance of both WASH services and OCV.

- **For Humanitarian Implementing Partners (NGOs)**

10. To leverage knowledge about cholera prevention measures and treatment through public awareness campaigns and health education programs. To empower communities to take proactive measures to prevent and respond to outbreaks.

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Annexes

Annex 1: The framework of factors associated with cholera endemicity (112)