Subject Area- World Studies: Health and Development (IB Subjects: Biology and Geography)

Title: Human impact on the outbreak of contagious diseases

Research question: To what extent are the effects of the proxy civil war (2014-present) the cause for the exacerbation of the cholera outbreak in Yemen?

Word count: 3992

Contents

Introduction

(a) Local Context

The UN has deemed Yemen the greatest contemporary humanitarian crisis, facing war, famine, cholera outbreaks and the coronavirus pandemic during a tumultuous time.

Yemen is the second-largest Arab state, bordered by Saudi Arabia, the Red Sea, the Gulf of Aden and Guardafui Channel and Oman (Wikipedia, 2020). The country is 'failed state' meaning that Yemen is "particularly vulnerable to internal and external shocks and domestic and international conflicts" (LSE, 2009).

From 2011-2012 there were a series of protests, which were led to address the failings of the government regarding unemployment rates, food insecurity, Yemen's failing economic conditions and the rampant corruption (Amnesty, 2020).

Over the course of the year, the protests shifted course and called for the resignation of President Ali Abdullah Saleh forcing him out of office. His deputy, Abd Rabbu Mansour Hadi, replaced him and founded the "National Dialogue Conference" (NDC), a conference that would see to reconciliation efforts after the revolution and calm the unrest through the country (Amnesty, 2020).

After two years, the NDC proposed a federal map that would partition Yemen into regions without accounting for socio-economic or regional differences (Amnesty, 2020). The map was met with great backlash from civilians and the Houthis, an Islamic political and armed movement based in the North Yemen, who used the unrest as a catalyst to increase their presence in Yemen. The Houthi control over Yemen has grown and solidified over the past six years.

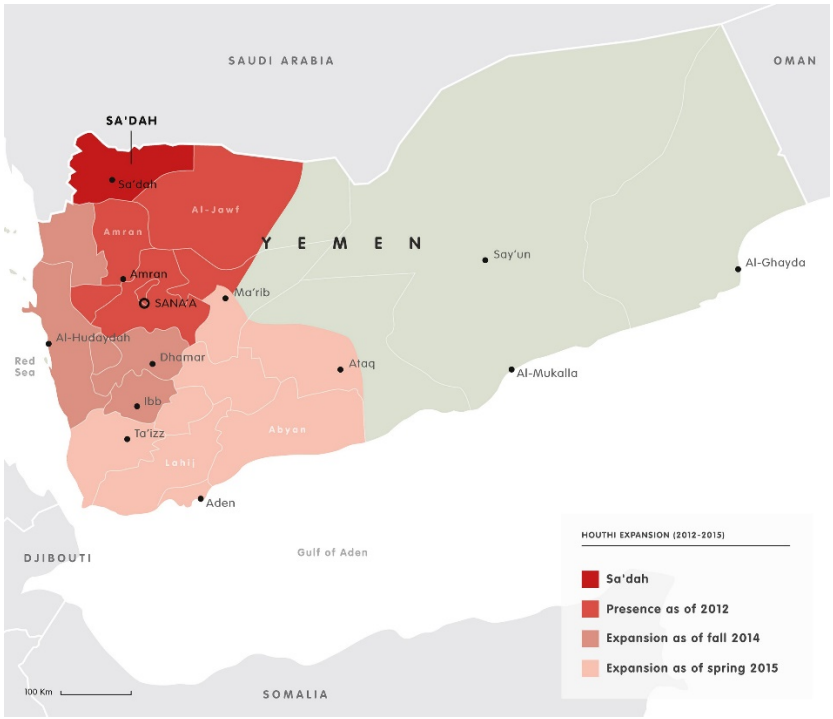

Figure 1 - A map showing Houthis expansion 2012-2013 (Harrison, 2019)

By September 2014, the Houthis had taken over the majority of army and security positions in the capital city, “facilitated to a certain extent by the newly forged alliance… with former President Saleh” (Amnesty, 2020). By early 2015, President Hadi and his board of governors had to flee the country. (Amnesty, 2020) By 25th March 2015, a coalition of nine countries including Saudi Arabia and the United Arab Emirates led an intervention at the behest of President Hadi against the Houthi rebels (Amnesty, 2020). This marked the beginning of a five-year proxy war (Amnesty, 2020).

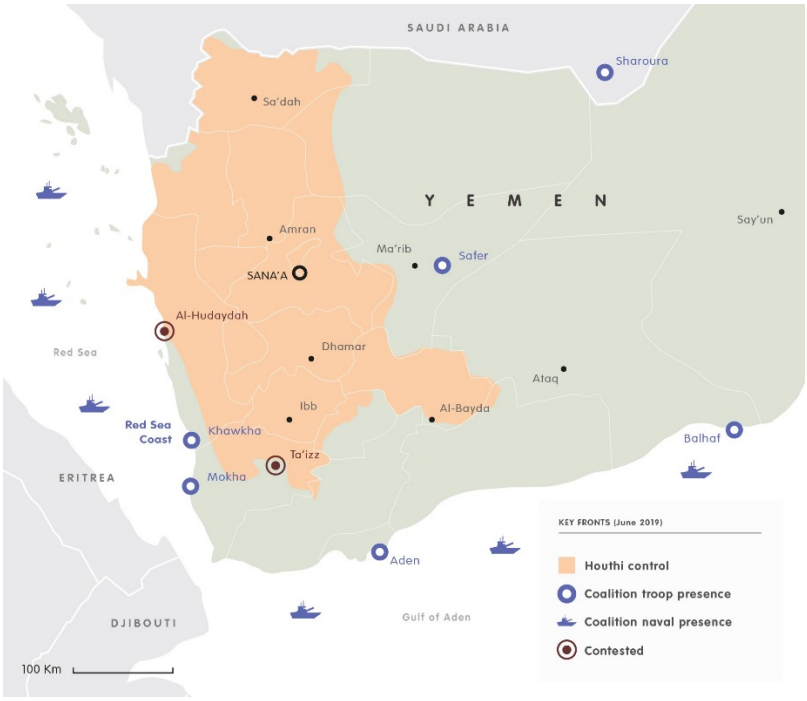

Figure 2 - A map showing the key fronts (Harrison, 2019)

The first confirmed cases of cholera in Yemen began in late September 2016 “from Sept 28, 2016, to March 12, 2018, there were 1,103,683 suspected cholera cases and 2385 deaths were reported countrywide.” (Camacho, et al.).

At this point, the coalition had strategically bombed and greatly damaged the medical facilities and water infrastructures in place.

The main source of water in Yemen is withdrawn from wells, springs and boreholes and this led to severe groundwater depletion (Fanack, 2019). Therefore, access to safe drinking water was scarce and due to high demand, prices steeply rose. Yemeni civilians had to pay over 30% of their income to have clean water in their household (Mis, 2015), as majority of the population live on less than $2 a day, they aren’t able to afford it leaving millions of people with little access to clean water (Mis, 2015).

By September 2016, “less than 50% of the hospitals were still in operation” (Breugem, et al., 2019) placing higher demand on the already taxed healthcare

system. As the pace of the war increased, the Houthi's government personnel cut a sizeable portion of public expenses to afford the arms needed in the war, resulting in the collapse of the waste system, creating rapid accumulation of waste contaminating the water system (Breugem, et al., 2019). As normal means of supplying and storing water have been severely damaged by the bombing, Yemenis have resorted to collecting water in buckets when it rains.

The sewage system in Sana'a collapsed on the April 14th, 2017. This is significant because a study found that leachate, discharge from nearby landfills produced by the mixing of rainwater and waste, escaped from the site and was found in nearby boreholes (Sabahi, et al., 2009). A WASH (Water, Sanitation and Hygiene) assessment found between 2014 and 2018, waste collection decreased in urban areas and rural areas. 89% reported that their domestic rubbish was not collected, a figure that correlated with increased rates of open burning and dumping. A third reported they disposed of their waste through burning or dumping, whilst over half left their waste in public areas expecting it would be collected (WASH Cluster, 2018).

(b) Global context

Cholera is a global public threat as well as "one of the key indicators of poor social development" (Stoltzfus, et al., 2014) in a country. Cholera outbreaks tend to occur in low-income countries (LICs) that have poor water and sanitation facilities, have undergone conflict leading to the loss of these infrastructures or both.

The global rate of cholera infections has increased in the last two decades with 589,854 reported cases and 7816 reported deaths (Stoltzfus, et al., 2014) however the WHO estimates that these officially reported cases only represents "5–10% of the actual number occurring annually worldwide" (World Health Organisation, 2012).

They estimate that the actual number of cases ranges from 3-5 million and “of the estimated 3-5 million cases that occur globally every year, about 100 000 to 120 000 die” due to lack of suitable treatment. (World Health Organisation, 2012). As cholera is a communicable, water-borne disease, it is greatly impacted by human activity.

For example, the cholera outbreak in Haiti 2011, was a result of the mismanagement of waste at a UN peacekeeping camp that infected over “770,000 Haitians and claimed over 9,200 lives” (Sider, 2016).

Zimbabwe, 2008-2009, experienced a cholera outbreak largely due to political scruples as “loss of municipal elections in Zimbabwe in 2005 led party leaders to refuse to fund municipal budgets for cities where it had been defeated” (Cuneo, et al., 2017). This led to “the redirection of raw human sewage into the city’s main reservoir” (Cuneo, et al., 2017) and the contamination of it. This bears similarities with Yemen as most of the population had no access to clean water and waste collection ceased.

This essay focuses on the causes of the exacerbation of the cholera crisis in Yemen. Cholera is an indicator of poverty and lack of social development and infrastructures, which makes this investigation of global importance.

(c) Research Methodologies

To answer my research question as thoroughly as possible, I chose a World Studies essay with Biology and Geography as my interdisciplinary subjects. All my research data were secondary sources found on Google Scholar or PubMed. I chose these two ‘libraries’ because they had academic journals that I felt would be more reliable. Academic journals are highly specialized, allowing for a deeper understanding of topics such as the pathogenesis of cholera. Also, academic journals are all peer-

reviewed, this leads to less bias work being published. This is to ensure that the academic articles are scientifically valid, and they meet publisher's standards of quality.

I also read articles that reported on the crisis in Yemen from websites like the National Geographic and the World Health Organisation (WHO) as well as other non-governmental (NGO) websites when looking for reports and data such as mortality rates. I chose to read these articles as they would be factual and less prone to biases that might be in articles from newspapers. I did, however, cross-reference everything I read as much as possible when reading articles from newspapers with articles and data from the WHO and the National Geographic to fact check and put things into context.

Biological Perspective

(a) Background of cholera

"Cholera is an acute diarrhoeal infection caused by ingestion of food or water contaminated with the bacterium *Vibrio cholerae*." (World Health Organisation, 2019). It takes between twelve hours to five days for a victim to show symptoms after the ingestion of cholera contaminated water or foods. When caught early, 80% of cases can be treated with oral rehydration and the more severe cases with intravenous fluids and antibiotics (World Health Organisation, 2019).

Most who catch cholera only show moderate symptoms for a few days but are not fatal cases, although the bacteria can be present in the stool of infected victims for one to ten days (World Health Organisation, 2019), increasing the potential chance of others getting infected as the bacteria from the stool may infect water or food supplies.

This is the most common way for cholera to quickly spread as cholera tends to be prevalent in areas with poor sanitation. The reason why most victims develop moderate symptoms whilst some develop more acute ones is that the majority of the bacterial vibrios species do not trigger the acute symptoms caused by the toxins released from *Vibrio cholerae*. (Finkelstein, 1996).

(b) The pathogenesis of cholera

Cholera is characterised by the secretion of numerous, voluminous, watery stools, and is often accompanied by vomiting, resulting in hypovolemic shock. This is a life-threatening condition where one loses more than one-fifth of one's body's fluid supply, "this severe fluid loss makes it impossible for the heart to pump a sufficient amount of blood to your body" (Healthline, 2020), this means they will not be able to maintain an acceptable blood pressure to supply oxygen to their organs particularly, the heart, brain, kidneys, and liver. As well as acidosis, "a process causing increased acidity in the blood and other body tissues" (Wikipedia, 2020). It is caused by some members of the *Vibrio cholerae* species.

"Vibrios are highly mobile, gram-negative, curved or comma-shaped rods with a single polar flagellum" (Finkelstein, 1996). Humans are "the only natural hosts" for the bacterium (Finkelstein, 1996). Gram-negative bacteria "have a thin peptidoglycan layer and have an outer lipid membrane (Steward, 2019)". This cells wall allows gram-negative bacteria walls to withstand approximately 3 atm (atmospheric pressure) of turgor pressure, enables them to endure extreme temperatures and pHs and also expand several times their normal surface area (Beveridge, 1998). The peptidoglycan layer also prevents excess amounts of water to enter the bacterium.

The bacteria is prototrophic, this mean that it grows in media containing inorganic nitrogen sources, the major forms being “nitrogen gas, nitrate, nitrite, and ammonium (Dodds & Whiles, 2019)”, a “utilisable carbohydrate”, glucose as their carbon and energy source, amongst other minerals. In optimum media, they have a generation time of fewer than thirty minutes. *Vibrio cholerae* is a facultative anaerobe, an organism that can survive in the presence of oxygen, use oxygen for aerobic respiration, but can also survive without oxygen, using anaerobic respiration (Biology Dictionary, 2018), thus they can also grow in anaerobic conditions. Cholera uses faecal-oral transmission, where pathogens in faeces are transmitted from matter to the mouth of people due to poor sanitation and hygiene practices.

The bacterium can tolerate alkaline media which typically kills intestinal commensals (organisms that derive benefits from another without harming or helping it) due to their cell wall. Unlike most gram-negative bacteria, they are sensitive to low pH and reach fatality in solutions below pH six, thus most die in the stomach. The surviving bacteria move on to colonize the small intestine where absorption of nutrients and minerals from food occurs. This can be fatal in many cholera cases, especially in an area such as Yemen where due to the man-made famine, the average civilian has little food and the food they have digested that would be used for processes such as respiration would be absorbed by the bacterium.

They then proceed to colonise the small intestine; an area is normally free of bacteria due to effectiveness of peristalsis and mucus secretion. This might allow the bacteria to efficiently multiply as they have no other competitors as well as “one or more adherence factors that enable them to adhere to the microvilli” (Finkelstein, 1996), which is most likely consists of multiple structures. Their mobility enabling them to penetrate the mucus layer, their production of mucolytic enzymes, enzymes

which thins mucus layers, helping the bacterium settle and neuraminidase, a viral protein, which aids bacterium and viral cells lyse from their host cells (Finkelstein, 1996). Here they secrete a potent cholera enterotoxin, which is a protein exotoxin that is produced by microorganisms that target the intestine (Wikipedia, 2020), consisting of two regions: The ‘A’ and ‘B’ regions.

The ‘A’ region is responsible for the activity of the toxin and the ‘B’ region binds the toxin to its receptors on the host cell membranes. The toxins bind through region ‘B’ to a glycolipid, which is present in all eukaryotic cell membranes. Region ‘A’ penetrates the host cell and transfers ADP-ribose from nicotinamide adenine dinucleotide, a co-enzyme found in every cell and is involved in hundreds of metabolic processes (Elysium Health, n.d.), to a target protein, a GTP-binding regulatory protein which is associated with adenylate cyclase. Adenylate cyclase has key regulatory roles in all cells, it catalyses the conversion of ATP into cyclic adenosine monophosphate (cAMP) and pyrophosphate (The School of Biomedical Sciences Wiki, 2017). A reaction with the cholera enterotoxin “turns” adenylate cyclase “on”, leading to an exponential rise in the production of cAMP production (Finkelstein, 1996).

Whilst the series of events caused by the excessive production of cAMP has not been delineated, the final effect is the hypersecretion of water and electrolytes, particularly chloride and bicarbonate into the intestinal lumen.

Chloride, Cl^-, helps to maintain the balance between intracellular and extracellular fluid and maintain adequate blood pressure and blood volume (University of Michigan, 2019). Bicarbonate, HCO^-_3, a by-product of metabolism, is exhaled as carbon dioxide, excreted and reabsorbed by the kidney to regulate the body's pH

(University of Rochester, 2020). This hypersecretion results in the characteristic severe, watery stool. In hospitalised patients, this could result in fluid loss of more than twenty litres a day (Finkelstein, 1996). As the stool can contain "10^8 viable vibrio per ml, such a patient could shed 2 x 10^{12} cholera vibrio per day into the environment" (Finkelstein, 1996).

As most cholera cases in Yemen were not fatal, this may mean that the bacterium was able to quickly spread through the nation because of the number of bacteria released by infected hosts. This also helps to explain the second wave, as people relocated from areas that experienced high cholera cases to areas of low cholera cases, majority of the internal migrants may have been asymptomatic. Thus, when they released their stools, and due to the collapsed sewage system, these stools infected the environment, food and other surfaces, it led to another cholera outbreak.

Geographical perspective

(a) The effects of the war

The conflict in Yemen is an ongoing one. Between the coalition led by Saudi Arabia and the Iran-backed Houthi rebels and as a result of the aerial bombing raids used by the coalition, by September 2016, "less than 50% of the hospitals were still in operation" (Breugem, et al., 2019). There is no doubt that the actions of the war greatly affected the nation's ability to address issues such as food availability, medical care and sanitation.

When the coalition struck and people inevitably needed aid, they could not go the hospitals as they were over-crowded. This led to Yemeni civilians moving across the country to escape the conflict. As they moved, some of them would be asymptomatic vectors of the cholera bacterium. When they arrive at their destination, they would

arrive in areas of higher population density, where the state of housing, water and sanitation facilities were poor due to the steadily rising influx of internally displaced people.

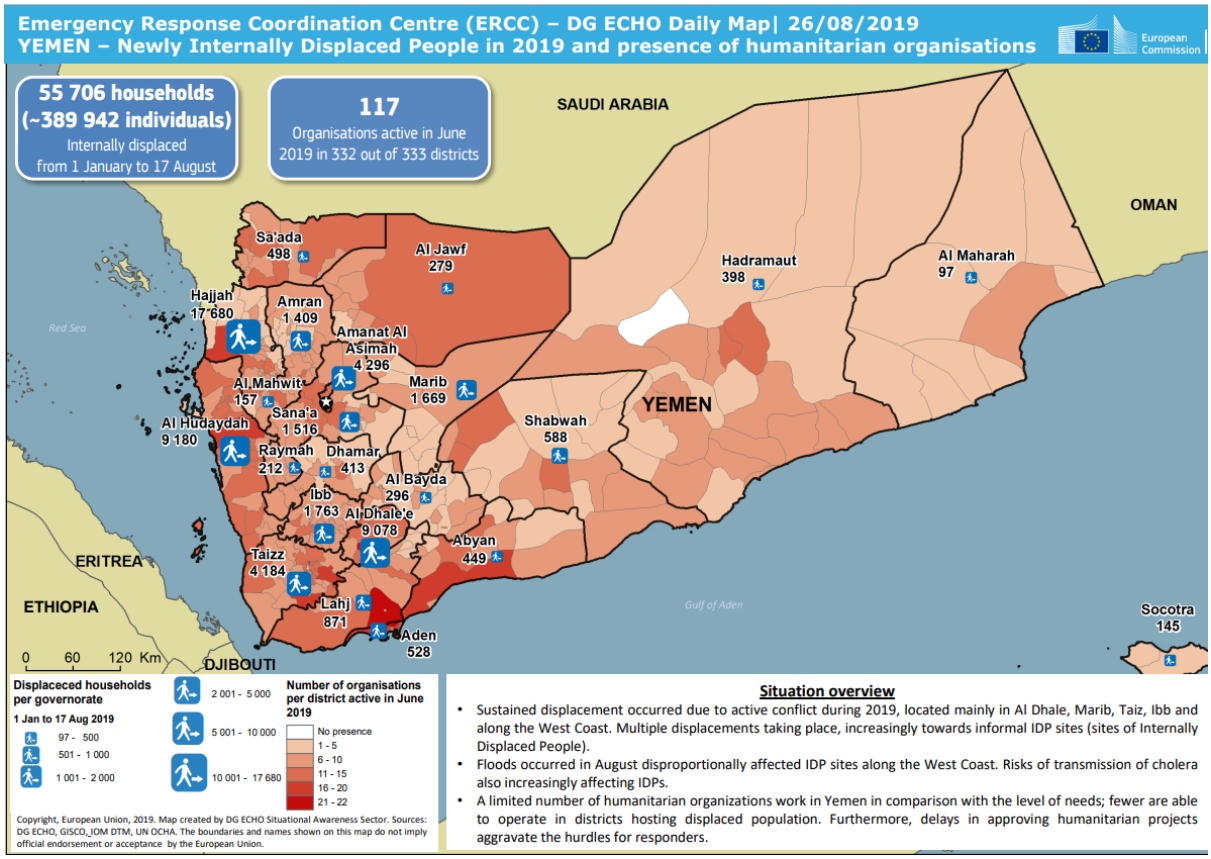

Figure 3 - An infographic showing the internal displacement of people in 2019 (European Commission's Directorate-General for European Civil Protection and Humanitarian Aid Operations, 2019)

This means that through expansion and relocation diffusion, the cholera bacterium was able to spread to other areas of Yemen that had rapidly falling standards of living. Expansion diffusion is when a disease spreads from one place to another, as the disease expands into new areas it is likely to weaken. Relocation diffusion is a “spatial spread process,” where the disease leaves the area where it originated as it moves into new areas (British Geographer, 2020).

(b) Famine as a factor

A human factor that exacerbated the effects of the cholera outbreak, especially in Houthi controlled areas, was the famine. Famine are events where populations lack basic access to food, leading to widespread malnutrition and deaths due to starvation or other co-morbidities (Maxwell, 2017). The three characteristics of a famine: if at least 20% of households in a given group face extreme food deficits, if at least 30% of children in a given group are acutely malnourished and if mortality rates exceed two people per 10,00 population per day (Maxwell, 2017).

Before the conflict began, “40 percent of the country was reported as food insecure” (Khairullin, 2020), approximately one million children under the age of 5 were stunted because of suffering from acute malnutrition and WASH infrastructures were limited (Ali & Federspiel, 2018).

In response to the missile strike on Saudi’s Riyadh airport on November 3rd 2017 by the Houthi-Saleh forces, to further put strain on the Houthi movement and to starve them out, the coalition staged a naval blockade, closing all of Yemen’s entry points from March 30th (Khairullin, 2020), preventing almost all aid and nearly all commercial imports from reaching Houthi-controlled ports. This significantly impacted the civilian’s access to essential goods, as Yemen imports 90% of its essential goods (Khairullin, 2020), exacerbating the food insecurity and threatened a generalised famine. Late November 2017, some restrictions were eased, the blockade was partially called off and essentials goods provided by NGOs began to enter, however, due to the immense demand, the prices of these goods rose by up to 90% (Khairullin, 2020) meaning that the average civilian could not afford them.

What the blockade did not let past was fuel, leading to fuel shortages around the country affecting the civilians as well as the country's hospitals. These shortages exacerbated the limited access to potable water Yemen faces as most of the water is pumped up using diesel generators. If there is no fuel, there will be no power, therefore people are not going to have potable water, meaning that people will end up using poor quality water.

(c) The environment and climate

There have been previous investigative studies into the cause of cholera outbreaks, and some have found positive correlation between periods of heavy rainfall and the risk and transmission of cholera. An example was a study conducted by Camacho and their team as they investigated the cholera outbreaks during the rainy seasons in Yemen so were able to establish associations between heavy rainfall and cholera cases.

They found that the *Vibrio cholerae O1 Ogawa strain* had been the same strain which had circulated twice in both waves, and a "positive, non-linear, association between weekly rainfall and suspected cholera incidence in the following 10 days; the relative risk of cholera after a weekly rainfall of 25 mm was 1·42 … compared with a week without rain." (Camacho, et al., 2018). This suggests that the first wave of the outbreak spread cholera throughout Yemen during the dry season and when the rainy season began in late April 2017, it led to the second outbreak (Camacho, et al., 2018).

However, another study by Paz suggested that suggested that "a combination of the impact of the strong El Nino of 2015-16 on cholera incidence in Horn of Africa, together with the following southwestern winds over the Gulf of Aden throughout the

summer of 2016, (Paz, 2019)" contributed to the dispersal of cholera from Somalia into Yemen. They suggest that chironomids, the natural reservoirs and carriers of the bacterium, were carried by the winds into Yemen, infecting the water and the people (Paz, 2019).

(d) Funding shortfalls and international humanitarian aid response

Another factor for the exacerbation of the cholera epidemic in Yemen was the delayed humanitarian response due to the lack of adequate funding and the naval blockade.

The first wave of the epidemic was from September 26th, 2016 to April 23rd, 2017. The initial response was from the WHO, who released $1 million from its emergency relief fund in response to the cholera outbreak and to provide temporary relief (OCHA, 2017). Before the cholera outbreak began in Yemen, The UN estimated that at least $2.1 billion would be needed to prevent "a full-blown humanitarian catastrophe in Yemen" however when the 'High-Level Pledging Event for the Humanitarian Crisis in Yemen' was held in Geneva on April 25th 2017, only $1.1 billion was raised by various intergovernmental organisations and ŃGOs (The Lancet Gastroenterology & Hepatology, 2017).

Another factor is the delay of Oral Cholera Vaccines (OCVs). These are vaccines that can play a vital role in the long-term control of cholera. They work by exposing the recipient to a small dose of live cholera bacteria, helping the body to build immunity to the disease. However, as it doesn't help to cure the patient if they already have cholera (University of Michigan, 2016), it is understandable why the WHO and other organisations decided to administer the vaccines later, but they could have effectively administered the vaccines earlier (Ali & Federspiel, 2018).

Despite the funding shortfalls and other restrictions on humanitarian responses, NGOs such as the Red Cross sent medical supplies such as IV fluids, ORS, antibiotics and chlorine tablets to help hospitals and aid the management of cholera, and helped to provide care to nearly 20% of cholera cases in Yemen. They dispatched engineers to help restore water supply systems when fuel was unavailable (Ali & Federspiel, 2018). UNICEF provided safe water to over one million people and delivered 36 tons of lifesaving medical and water purification supplies to Yemen including “750,000 sachets of Oral Rehydration Salt (ORS) enough to treat 10,000 people, 10.5 million water purification tablets and other sanitation items” (UNICEF, 2017).

These actions meant that even though there are over two million cases, the fatality rate was 0.17%.

Conclusion

The proxy civil war in Yemen between the Houthi rebels and the Saudi Arabia led coalition was undoubtedly a major factor in the cholera epidemic in Yemen. The bombing strikes led by the coalition strategically targeted medical facilities, left over 55% of medical facilities greatly damaged and unable to function, placed a greater strain on the taxed healthcare system, and destroyed water infrastructures in an effort to stress the Houthi controlled areas. The war also prevented necessary aid to enter the country. Due to the intensified war efforts, NGOs are facing restrictions and bureaucratic hurdles to get to the areas of greatest need. The war also led to the internal displacement of over three million civilians, allowing the bacterium to spread through expansion and relocation diffusion as people fled areas of conflict. Actions of the war also exacerbated the growing food insecurity in Yemen into a famine due to the blockade restrictions placed by the coalition.

The country experienced high food insecurity leaving over half the population of children stunted and could have left them more vulnerable to a fast-acting disease such as cholera. Only half the population had access to clean water and good sanitation prior to the outbreaks. The government stopped funding public health and sanitation sectors which led to the collapse of the sewage systems and the accumulation of waste in the country. This was particularly important as the monsoon season began after the stall of the sewage system in the capital city and the second wave of cases began just after ten days of the collapse. This led to stagnant, dirty water being the source of water for civilians, due to the fuel price they could not access potable water. The lack of international humanitarian response, especially seen in the funding, is another factor. Due to the shortfalls in funding, the reach was not as far as it could have been leaving civilians either completely helpless or partially aided.

To conclude, the war was a major factor and an exacerbation of the cholera epidemic in Yemen, it was an accelerant. The cholera outbreak was facilitated by an endemic state, widespread malnutrition, food insecurity, lack of clean water and sanitation facilities and the collapse of health services.

Bibliography

Ali , M. & Federspiel, F., 2018. The cholera outbreak in Yemen: lessons learned and way forward. *BMC.*

Amnesty, 2020. *YEMEN WAR: NO END IN SIGHT.* [Online]
Available at: https://www.amnesty.org/en/latest/news/2015/09/yemen-the-forgotten-war/
[Accessed 12 07 2020].

Breugem, T., De Munck, T., Reddy, S. & Van Wassenhove, L., 2019. *Behind the Scenes of Humanitarian Operations.* [Online]
Available at:
https://www.insead.edu/sites/default/files/assets/dept/centres/hrg/docs/INSEAD_HRG_-_mini-case_-_Cholera_in_Yemen.pdf
[Accessed 06 09 2020].

Camacho, A., Bouhenia, M. & Alyusfi, R., 2018. Cholera epidemic in Yemen, 2016–18: an analysis of surveillance data. *The Lancet Global Health,* 6(6).

Cuneo, C. N., Sollom, R. & Beyrer, C., 2017. The Cholera Epidemic in Zimbabwe, 2008–2009. *Health and Human Rights Journal.*

Dyke, J. & Mojalli, A., 2015. *Shipping ban deepens Yemen's fuel crisis.* [Online]
Available at: https://www.refworld.org/docid/5530dfb14.html
[Accessed 07 09 2020].

Finkelstein, R. A., 1996. Cholera, Vibrio cholerae O1 and O139, and Other Pathogenic Vibrios. *Medical Microbiology.*

Harrison, A., 2019. *Mapping the Yemen conflict..* [Online]

Available at: https://www.ecfr.eu/mena/yemen

[Accessed 09 07 2020].

Healthline, 2020. *Hypovolemic Shock.* [Online]

Available at: https://www.healthline.com/health/hypovolemic-shock

Khairullin, E., 2020. *Yemen, Naval Blockade.* [Online]

Available at: https://casebook.icrc.org/case-study/yemen-naval-blockade-0#:~:text=%5B3%5D%20The%20coalition%20began%20an,a%20naval%20and%20aerial%20blockade.

[Accessed 07 09 2020].

LSE, 2009. [Online]

Available at: https://www.lse.ac.uk/international-development/Assets/Documents/PDFs/csrc-background-papers/Definition-of-a-Failed-State.pdf

[Accessed 09 07 2020].

Maxwell, D., 2017. *21st century famines have nothing to do with a lack of food.* Davos-Klosters: World Economic Forum.

OCHA, 2017. *Yemen: Cholera Outbreak - Oct 2016.* [Online]

Available at: https://reliefweb.int/disaster/ep-2016-000107-yem

[Accessed 07 09 2020].

Orata, F. D., Keim, P. . S. & Boucher, Y., 2014. *The 2010 Cholera Outbreak in Haiti: How Science Solved a Controversy.* [Online]

Available at:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3974815/bin/ppat.1003967.g001.jpg
[Accessed 06 09 2020].

Sider, A., 2016. *How Cholera Spread So Quickly Through Haiti.* [Online]
Available at: https://www.nationalgeographic.com/news/2016/08/haiti-cholera-crisis-united-nations-admission/
[Accessed 18 11 2019].

Stoltzfus, J. D. et al., 2014. Interaction between climatic, environmental, and demographic factors on cholera outbreaks in Kenya. *BMC.*

The Lancet Gastroenterology & Hepatology, 2017. Health catastrophe: the toll of cholera in Yemen. *The Lancet Gastroenterology & Hepatology,* 2(9).

UNICEF, 2017. *UNICEF airlifts lifesaving supplies to Yemen to combat cholera as cases surpass 200,000.* [Online]
Available at: https://www.unicef.org/press-releases/unicef-airlifts-lifesaving-supplies-yemen-combat-cholera-cases-surpass-200000#:~:text=UNICEF%20airlifts%20lifesaving%20supplies%20to%20Yemen%20to%20combat%20cholera%20as%20cases%20surpass%20200%2C000,-28%20June%202017
[Accessed 07 09 2020].

University of Michigan, 2016. *cholera vaccine.* [Online]
Available at: https://www.uofmhealth.org/health-library/d08480a1#:~:text=This%20vaccine%20works%20by%20exposing,18%20through%2064%20years%20old.
[Accessed 07 09 2020].

Wikipedia, 2020. [Online]

Available at: https://en.wikipedia.org/wiki/Yemen

[Accessed 09 07 2020].

Wikipedia, 2020. *Acidosis.* [Online]

Available at: https://en.wikipedia.org/wiki/Acidosis

World Health Organisation, 2012. *The global burden of cholera.* [Online]

Available at: https://www.who.int/bulletin/volumes/90/3/11-093427/en/

[Accessed 06 09 2020].

World Health Organisation, 2017. *Oral cholera vaccines.* [Online]

Available at: https://www.who.int/cholera/vaccines/en/

[Accessed 07 09 2020].

World Health Organisation, 2019. *Cholera.* [Online]

Available at: https://www.who.int/news-room/fact-sheets/detail/cholera

[Accessed 07 09 2020].