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Cholera – management and prevention

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Summary Cholera is an acute secretory diarrhoeal infection caused by the bacterium *Vibrio cholerae*. It is likely to have originated in the Indian sub-continent; however, it spread to cause six worldwide pandemics between 1817–1923. The ongoing seventh worldwide pandemic of cholera began in 1961. The intensity, duration and severity of cholera epidemics have been increasing, signaling the need for more effective control and prevention measures. The response to the cholera pandemics of the 19th century led to the development of safe and effective sanitation and water systems which have effectively removed the risk of cholera in many settings. However, such systems are not in place to protect billions of people worldwide. Although some progress has been made in expanding access to water in recent years, achieving optimal infrastructure will, in the most optimistic scenario, take decades. Climate change, extreme weather events and rapid urbanisation suggests that alternatives to the current paradigm of providing large centralised water and sanitation systems should be considered, including smaller decentralised systems. The aim of this review paper is to provide an overview of current knowledge regarding management of cholera with a focus on prevention measures including vaccination and water and sanitation interventions.

Introduction

Cholera is an acute enteric infection caused by the gram negative bacterium *Vibrio cholerae,* a member of the vibiriniaceae family. [1] It causes a profuse secretory diarrhoea that can lead to rapid dehydration, hypovolaemia and death if not treated. In 2014, the World Health Organization reported a total of 190,549 cases of cholera. 55% of these reported cases occurred in Africa. The total case fatality rate was estimated by WHO to be 1.17%.[2] These reported figures are likely to be a gross underestimate of the true burden of cholera disease. Fear of negative impact on travel and trade, limitations in surveillance systems, inconsistencies in case definitions and lack of lab capacity

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all contribute to underreporting of cholera cases.[3] The true burden of disease is estimated to be between 1.4 and 4.3 million cases/year.[2]

History

Sanskrit writings from the Sushruta Samhita in India as early as 500–400 BC describe an illness that resembles cholera. It is thought to have remained confined to the Indian sub-continent until the first global pandemic that began in 1817.[4] It first reached Europe in 1829 and led to the formation of central and regional Boards for Health in Great Britain in preparation for the imminent arrival of the pandemic. It reached England in 1831 and large epidemics occurred between 1831–32 and 1848–49. In 1849 the English physician John Snow published his essay 'On The Mode of Communication of Cholera'. He discounted the widely held belief that cholera was spread by a 'miasma' coming from the river and proposed that cholera was a communicable disease and that infectious material was present in stool, that may be widely disseminated by the emptying of sewers into the drinking water of the community.[5] Snow proposed a number of preventative measures including hand washing, treatment or filtration of drinking water and creation of a sewage free water supply,[5] measures that remain key components of water and sanitation interventions to this day. Robert Koch later identified the bacterium and postulated that a toxin was responsible for the massive outpouring of fluid from the intestine.

The organism

The gram negative rods are found in coastal waters and estuaries.[6] There are over 200 recognised serogroups. However, only two of these are associated with epidemic cholera, serogroups O1 and O139. Serogroup O1 can be further classified by its serotype (Ogawa/Inaba) and biotype (Classical or El Tor). Prior to the 7th global pandemic of cholera, the majority of cholera isolates were the Classical biotype of the O1 serogroup and El Tor isolates were responsible only for sporadic cases of diarrhoea. However, since 1961 the vast majority of isolates have been El Tor type.[7] Since 1992 serogroup 0139 Bengal has emerged as a human pathogen.[8]

Transmission

Since the early discoveries of Snow and Koch a huge amount has been discovered about the ecology and transmission of *V. Cholerae*. Cholera vibrios inhabit seas, estuaries, brackish waters, rivers and ponds in coastal areas. They thrive in saline water, however, they can also live in water of lower salinity if it is sufficiently warm and contains a high concentration of organic nutrients.[9] *V. Cholerae* live in a commensal relationship with copepods.[10] These tiny planktonic crustaceans serve as the normal host organism for vibrios. Copepods utilise phytoplankton as their food source. A study conducted in two coastal communities in cholera endemic areas of Bangladesh and India found that outbreaks were preceded by phytoplankton blooms.[11]

The linkage between weather, phytoplankton blooms and the prevalence of cholera vibrios in the environment suggests that climate change may affect cholera ecology and so its epidemiology. In 1992 the seventh pandemic of cholera reached Peru in South America and quickly spread along the entire coast from the Ecuadorian to the Chilean borders. This outbreak coincided with strong El Niño currents and plankton blooms.[9,12] Thus it is likely that a complex interplay between macro and micro environmental factors including water temperature, salinity, nutrient concentrations and plankton all influence the amount of vibrios in environmental reservoirs.

Cholera can be transmitted to humans via ingestion of water contaminated with infected copepods. It can also be transmitted from person to person via the faecal-oral route and may be acquired from contaminated food or water. The stools of those afflicted by *V. cholerae* are extremely infectious as they contain up to 10^9 vibrios per ml.[13] *V. cholerae* genes coding for a hyperinfectious phenotype are expressed as the bacteria move towards the distal intestine, making *V. cholerae* excreted by human hosts more contagious than *V. cholerae* extant in a natural environment. After they are purged from the human intestine they remain in this hyperinfectious state in the environment for hours to days, and so can efficiently propogate an epidemic.[14,15]

When *V. cholerae* is ingested, the organisms must withstand the acidic environment of the stomach in order to colonise the intestines. In a healthy individual, the infectious dose of bacteria is estimated to be 10^5–10^8 organisms. However, hypochlorhydria as a result of malnutrition, or medications to reduce gastric acid can lower the infectious dose. Host factors make some people more susceptible to infection, in particular persons with blood group O are significantly more likely to develop severe cholera disease.[16,17]

Epidemiology

Endemic cholera

Cholera occurs in both endemic and epidemic patterns. It is endemic in 69 countries in Asia and Africa where an estimated 1.3 billion people are living at risk of cholera.[18] In 2013, over 190,000 cholera cases were reported to the WHO from 47 different countries, this is likely to be a gross underestimate of the true burden of disease.[2] Countries with estimates of more than 100,000 cases annually include India, Ethiopia, Nigeria, Haiti, The Democratic Republic of the Congo, Tanzania, Kenya and Bangladesh.[18] It can occur seasonally in some endemic settings and is temporally associated with monsoon rains and floods in the Asian subcontinent.[19] In endemic settings children bear the greatest burden of disease.[20]

Epidemic cholera

Cholera epidemics occur superimposed on endemic disease in long cycles. These cycles are determined by waning levels of population immunity and periods of climate variability.[1] When introduced into a cholera naive population, large epidemics can occur such as the ongoing Haitian epidemic that began in 2010. In epidemic settings where there is little or no natural immunity present, all age groups are equally affected by the disease. Epidemics occur unpredictably and are often associated with natural disasters and humanitarian

emergencies that disrupt access to water and sanitation supplies. Outbreaks are associated with high mortality and the case fatality rate rarely drops below 1%. In 2013, case fatality rates of <1% were reported in only 4 countries, case fatality rates of 1–5% were reported in 17 counties and rates greater than 5% were reported in 5 African countries including Guinea, Sierra Leone and Tanzania.[3] These high rates represent deficiencies in health systems.

Pathophysiology

Humans are the only known natural vertebrate host for *V. cholerae.* Its ability to colonise the small intestine is driven by the fimbrial toxin coregulated pilus which promotes adherence of the bacterial cell wall to intestinal mucosal epithelium. Toxin coregulated pilus also protects the bacterium from intestinal toxins and facilitates interaction with other *V. cholerae* bacteria, allowing for colony formation.[21]

V. cholerae does not invade the intestinal cells and its pathogenicity is actually secondary to the effect of the holotoxin cholera toxin, which it secretes. Cholera toxin is an AB_5 subunit type toxin, and so consists of 5 physiologically inactive B subunits which bind to the GM1 ganglioside receptors in small intestinal mucosa. Once attached, the A subunit is then trafficked into the intestinal cells where intracellular cyclic AMP (cAMP) is increased secondary to the A subunit's effect on adenylyl cyclase.[22]

Increase in intracellular cAMP results in increased chloride ion secretion from mucosal crypt cells and reduction in villus sodium chloride absorption. This results in massive secretory loss of electrolyte rich fluid into the bowel lumen and subsequent watery diarrhoea. Cholera toxin also has an inhibitory effect on the large bowel's ability to resorb.[22]

The genes for cholera toxin (*ctxab*) are found within the genome of CTXφ, a bacteriophage which infects *V. cholerae.* Ancestral *V. cholerae* DNA did not code for *ctxab*. CTXφ infects *V. cholerae* via the toxin coregulated pilus which is coded for by the vibrio pathogenicity island. All seven pandemic strains of *V. cholerae* contained this island.[1,13]

Clinical manifestation

Symptoms

The disease cholera manifests as an acute watery diarrhoea and can be lethal within hours of symptoms appearing. The incubation period is typically a few hours to five days.[23] Its presentation ranges from asymptomatic to mild, moderate or severe. About 80% of people infected with *V. cholerae* do not develop symptoms (but do shed the bacteria in their stool for up to 10 days after infection). Of those who develop symptoms, about 20% will have severe symptoms.[24]

In severe cholera, diarrhoeal loss can exceed 1L per hour and so can be extremely dangerous in untreated patients. Cholera can kill up to 70% of untreated patients with severe cholera.[1,22] Diarrhoea is most prominent for the first one to three days of the illness. It is usually watery, non-bloody and non-mucoid, and described as 'rice-water stool' as it has a similar appearance to the starchy water in which rice has been cooked or washed. It may have a fishy odour.[1] Though cramping and abdominal discomfort can occur, the disease is typically painless and there is usually no fever. Borborygmus and vomiting can occur.

The most dangerous complications of the disease are dehydration and electrolyte disturbance. The watery stool of cholera is rich in sodium, chloride, bicarbonate and potassium.[25] Hypokalaemia can result in muscle cramping and weakness as well as cardiac arrhythmias and ileus. Hypocalcaemia can produce muscle spasms and tetany. Metabolic acidosis can occur as a result of bicarbonate loss and the lactic acidosis of hypoperfused tissue. Hypoglycaemia can occur (especially in children with low glycogen stores) and if not corrected can lead to central nervous system dysfunction such as altered consciousness or seizure.[1,26,27]

Secondary complications as a result of dehydration have also been observed. These include hypothermia, stroke, renal tubular necrosis and total circulatory collapse.[13] Vomiting can lead to aspiration pneumonia.[27] There is an increased risk of foetal death in pregnant women with cholera.[28]

Signs

Signs of dehydration in the presence of a profuse watery diarrhoea characterise the clinical picture. The patient may have dry mucus membranes, sunken eyes, tenting of the skin and can feel cool and clammy to touch. A peripheral tachycardia will be present and may become more difficult to palpate as dehydration worsens. Hypotension can occur. Oliguria may be present and can progress to anuria. Kussmaul's breathing can occur if the patient is acidotic. The assessment of dehydration should use both objective and subjective measures (see Table 1).[29]

Diagnosis

The World Health Organization has developed a case definition for cholera (see Table 2).[23]

Laboratory tests are not essential for diagnosing cholera as the clinical picture of acute, non-bloody, profuse, watery diarrhoea quickly leading to dehydration does not occur in many other scenarios. However WHO does recommend that for the first ten to twenty cases, samples be collected to confirm the outbreak. Once confirmed, samples need not be collected from every patient – however it may be useful to collect samples at regular periods during an outbreak for antibiotic sensitivity testing. Diagnostics are also useful for epidemiological studies.

The Centers for Disease Control (CDC) and World Health Organization (WHO) recommends isolation and identification of *V. cholerae* serogroup O1 or O139 by culture of a stool specimen as a gold standard.[30,31] *V. cholerae* does not grow on many of the media used for other gastrointestinal pathogens. Selective thiosulfate–citrate–bile salts agar (TCBS) is the ideal culture plate for isolation and identification of the bacteria. Carey-Blair medium or peptone water should be used as the transport medium.[31] Serogroup and serotype can be identified using specific antisera.

Dark field microscopy can be used to quickly evaluate whether stool samples contain *V. cholerae* organisms by observing for their darting ("shooting-star") movements, which can then be inhibited by using certain antisera.[32]

Table 1 Assessment of severity of dehydration in a patient with diarrhea.

	No Dehydration	Some Dehydration (If two or more signs with at least one **bold** sign)	Severe Dehydration (If two or more signs with at least one **bold** sign)
General Inspection	Well, alert	**Restless, irritable**	**Lethargic, unconscious, floppy**
Eyes (Tears are relevant only for infants and young children)	Normal, tears present	Sunken, tears absent	Sunken, dry, tears absent
Tongue	Moist	Dry	Very dry
Skin Pinch (May be less useful in those with marasmus, kwashiorkor or obesity)	Normal	**Goes back slowly**	**Goes back very slowly**
Inquire about thirst	No thirst	**Thirsty, drinks eagerly**	**Unable to drink, drinks poorly**

Other signs of severe dehydration in adults and children >5 include **absent radial pulse** and **low blood pressure**.
Adapted from World Health Organization. Management of the Patient with Cholera Online: World Health Organization; 2004.[29]

Table 2 WHO Case definition of cholera.

Suspected case:
- 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.
- For management of cases of acute watery diarrhoea in an area where there is a cholera epidemic, cholera should be suspected in all patients with acute watery diarrhoea.

Confirmed case:
Any suspected case confirmed by laboratory through isolation of Vibrio cholerae 01 or 0139 from stool in any patient with diarrhoea.

Outbreak threshold
One confirmed case of Cholera is an outbreak.

Rapid diagnostic tests do exist in the form of an immunoassay dipstick, the most common being the Crystal VC, but its sensitivity and specificity are suboptimal. It can be used as a screening tool in areas where lab testing facilities are poor. However, The CDC recommend that any stool sample testing positive with a Crystal VC dipstick should be confirmed by a stool culture.[31,33]

V. cholerae diagnosis via polymerase chain reaction (PCR) has been developed and demonstrates high sensitivity and specificity. A multiplex method can identify toxigenic genes and therefore differentiate virulent *V. cholerae* from other vibrio species and other bacteria.[34] Blood tests for electrolytes can be useful in severe cases complicated by electrolyte deficiency and renal injury.

Management

The mainstay of treatment involves fluid repletion. As most fatality in cholera is secondary to massive dehydration and electrolyte loss, replacement of fluid is an extremely effective treatment and significantly lowers mortality. The most common mistake in the treatment of cholera is under-administration of fluid. Those suffering from cholera typically are more dehydrated and have a higher rate of fluid loss (10 to 20 ml/kg/hr) than those suffering from other forms of gastrointestinal illness,[35] therefore their losses must be matched appropriately, and maintenance fluids then prescribed to cover for ongoing loss. WHO have devised a treatment strategy of fluid replacement based on the clinical picture of dehydration (see Figure 1).[29]

Most patients with mild to moderate cholera can be managed with oral rehydration solution (ORS) which reduces the need for intravenous fluids. Rice based ORS reduces the amount of stool lost in severe cholera.[36] Those with severe cholera usually require 200 ml/kg of intravenous fluid replacement in the first 24 hours of therapy. Ringer's Lactate is an appropriate polyelectrolyte fluid treatment. Other locally prepared solutions such as "Dhaka's solution," which contains more potassium than Ringer's Lactate are sometimes available in endemic areas. ORS should be used alongside intravenous therapy as it is richer in electrolytes and glucose than standard intravenous therapy.[35]

If possible, patients with severe cholera should be monitored with a cholera cot (Figure 2). This allows for monitoring of ongoing fluid loss so appropriate fluid replacement can be prescribed.

When able the patient should eat and breastfeeding should be encouraged in infants alongside ORS treatment. In children, one study found that zinc treatment shortened the duration of diarrhoea by 12%.[37] WHO recommends zinc treatment in children less than five years of age with diarrhoea. Anti-motility treatments such as loperamide are not recommended as they can lead to intestinal pooling of fluid and thus create pretence of recovery.[13]

No dehydration

(fluid deficit <5% of body weight)

(fluid deficit <50ml/kg body weight)

Give ORS packets to take home.
Give enough packets for 2 days.
Demonstrate how to prepare and give the solution.
The caretaker should give the patient this amount of ORS solution:

Age	Amount of ORS after each loose stool
<24 months	50 - 100 ml
2 - 9 years	100 - 200 ml
10 years or more	As much as wanted

Instruct the patient or the caretaker to return if any of the following signs develop:

- Increased number of watery stools
- Eating or drinking poorly
- Marked thirst
- Repeated vomiting

Or if any signs indicating other problems develop:

- Fever
- Blood in stool

Some dehydration

(fluid deficit 5 – 10% of body weight)

(fluid deficit 50-100ml/kg body weight)

Administer ORS solution in the amount recommended

Approximate amount of ORS solution to give in the first 4 hours

Age[1]	Less than 4 months	4-11 months	12-23 months	2-4 years	5-14 years	15 years or older
Weight	Less than 5 kg	5-7.9 kg	8-10.9 kg	11-15.9 kg	16-29.9 kg	30 kg or more
ORS solution in ml	200-400	400-600	600-800	800-1200	1200-2200	2200-4000

If the patient passes watery stools or wants more ORS solution than shown, then give more.

Use the patient's age only when you do not know the weight. The approximate amount of ORS required (in ml) can also be calculated by multiplying the patient's weight (in kg) times 75.

Monitor the patient frequently to ensure that ORS solution is taken satisfactorily and to detect patients with profuse ongoing diarrhoea who will require closer monitoring.

Reassess the patient after 4 hours

If signs of severe dehydration have appeared (this is rare), rehydrate for severe dehydration

If there is still some dehydration, repeat the procedures for some dehydration, and start to offer food and other fluids.

If there are no signs of dehydration, then treat as 'no dehydration.'

Severe dehydration

(fluid deficit >10% of body weight)

(fluid deficit >100ml/kg body weight)

Give IV fluid immediately to replace fluid deficit. Use Ringer's lactate solution or, if not available, normal saline.

Start IV fluid immediately.
If the patient can drink, begin giving ORS by mouth while the drip is being set up.

For patients aged 1 year and older, give 100 ml/kg IV in 3 hours, as follows:

- 30 ml/kg as rapidly as possible (within 30 minutes);
- then 70 ml/kg in the next 2.5 hours.

For patients less than 1 year, give 100 ml/kg IV in 6 hours, as follows:

- 30 ml/kg in the first hour;
- 70 ml/kg in the next 5 hours.

Monitor the patient very frequently. After the initial 30 ml/kg have been given, the radial pulse should be strong (and blood pressure should be normal). If the pulse is not yet strong, continue to give IV fluid rapidly.

Give ORS solution (about 5 ml/kg/h) as soon as the patient can drink, in addition to IV fluid.

Reassess the patient after 3 hours (infants after 6 hours). If there are still signs of severe dehydration (this is rare), repeat the IV therapy already given.

Once less dehydrated, follow guidance for 'some' or 'no' dehydration.

Figure 1 Fluid replacement in acute diarrhoeal illness. Adapted from World Health Organization. Management of the Patient with Cholera Online: World Health Organization; 2004.[29]

Figure 2 Cholera cot. Photograph courtesy of Dr Asma Aziz – Research Investigator – IDD

Antibiotics

As fluid replacement forms the core of cholera management, antibiotic therapy is adjunctive. Antibiotic therapy shortens recovery time and so reduces the need for rehydration.[38] It also reduces the duration that *V. cholerae* is excreted in the stool from 5 days to 1 to 2 days, and so reduces subsequent transmission risk. Many antibiotics including tetracycline, co-trimoxaxole, doxycycline, ciprofloxacin, erythromycin and azithromycin have been shown to be effective at treating cholera, though these studies were conducted during a time when antimicrobial resistance was less widespread. Treatment should be based on local resistance patterns.[1,22]

Guidance differs on when antibiotics should be administered. WHO and Medecins San Frontiers (MSF) recommends the use of antibiotic treatment in patients with 'severe dehydration' only, whereas Pan American Health Organization (PAHO) and the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDCR,B) recommend antibiotic use in those with 'some' or 'severe dehydration'.[24,38–41]

Prevention

Between 1831 and 1854 London experienced 3 large epidemics of cholera. In 1854 alone, there were an estimated 20,000 deaths in the city.[42] The pioneering work of John Snow provided epidemiological evidence of the association between faecal contamination of water and cholera. Between 1859–1865, the London sewage system was built. It was designed and supervised by the Chief Engineer

to The Metropolitan Board of Works Sir Joseph William Bazalgette. In conjunction with Colonel William Haywood, he supervised the design and building of an elaborate system for the disposal of London's sewage. The three main objectives for the build were waste disposal, land drainage and introduction of a safe water supply.[43] Bazalgette's construction abolished cesspools and constructed greater than 1,300 miles of street sewers and 82 miles of main intercepting sewers.[42] Three and a half million cubic yards of earth were excavated and the construction cost a total of 4.1 million pounds.[42] Implementation of this centralised sanitation intervention prevented faecal contamination of water and effectively eliminated the risk of cholera in London. This centralised model of waste management has been replicated in weathy cities worldwide and forms the basis of waste disposal models in high-income countries.

Water technologies are designed to source, treat, distribute, and monitor the supply of water,[44] whilst sanitation technologies isolate, transport, and treat faecal waste and reduce the transmission of pathogens. Implementing water and sanitation services is costly and this has prevented their widescale implementation in many areas. The exact costs of different sanitation systems vary widely by setting and are influenced by population density, availability of construction materials and site conditions; even within a country, costs may vary widely from region to region.[45] Building a traditional centralised sewage system such as that built in London in the 1800s requires a significant infrastructure, high capital costs and expertise and funding for ongoing maintenance.

Compared with 1990, in 2015 a larger proportion of communities met Millennium Development Goals targets for water and sanitation, but these targets provide little reassurance of a reduction in community exposure to faeces. An estimated 1.8 billion people globally drink water from a source that is faecally contaminated.[46] Cities commonly met Millennium Develop Goals targets for sanitation by increasing the number of toilets. However, the contents of many of these latrines are dumped back into the immediate environment when they are filled, and the community remains highly exposed to faeces. A study evaluating 12 cities in Latin America, Africa, and Asia found that almost two-thirds of households relied on on-site sanitation facilities and of these faecal waste was managed safely in only 22%.[47] WHO estimates that up to 90% of wastewater in developing countries is discharged untreated directly into rivers, lakes and the ocean.[48]

Continuous provision of piped water of high microbial quality and sewered sanitation systems, such as those implemeted in London are an effective way of decreasing cholera risk, but the costs of such systems have limited widescale implementation in low-income countries. One alternative approach is decentralised sanitation systems to manage wastewater locally.[49] Decentralized systems avoid the enormous construction costs and ongoing energy and water costs to move faeces to centralized locations for treatment. Decentralized systems include primary treatment – in sedimentation ponds, settlers, septic tanks or bio-digesters, secondary treatment – in anaerobic baffled reactors, anaerobic filters or anaerobic and facultative pond systems, secondary aerobic/facultative treatment – in horizontal gravel filters and finally post-treatment – in aerobic polishing ponds.[49] Decentralized systems can be designed flexibly and scaled depending on the local needs.[49]

During an outbreak of cholera, public health authorities face many demands on scarce resources. Ensuring front line providers have the supplies and knowledge to treat the severe dehydration associated with cholera can save thousands of lives. Encouraging households to treat diarrhoea with oral rehydration solution, to treat drinking water with an effective disinfectant, e.g. chlorine, and to wash hands with soap can all contribute to reducing the burden of cholera.

In many settings where outbreaks occur, they are detected late due to limited surveillance and overburdened healthcare systems. The lack of a well-resourced response and stretched healthcare infrastructure systems means that outbreaks can grow rapidly and case fatality rates are often high.[3] In addition to implementation of water, hygiene and sanitation interventions, vaccines have been used in efforts to control outbreaks. Oral cholera vaccines have been developed and tested in a number of large studies and have demonstrated protective efficacies of 60–85% for 2–3 years.[50,51]

Shanchol is an oral cholera vaccine that contains whole killed *V.cholerae* cells without the addition of the B subunit. It was developed and manufactured in India and is priced at $1.85 per dose. This makes it affordable for use in low-resource settings as a tool to be used in an epidemic.[52,53]

In 2010, the World Health Organization endorsed the use of oral cholera vaccines as an additional tool to be used in control efforts against cholera in endemic settings based on demonstrated effectiveness from a number of large studies. The WHO also specified that cholera vaccines should be considered in areas at risk of outbreaks.[54] In 2012 a technical working group was convened in order to create a global stockpile of oral cholera vaccine for emergency response in outbreak situations and a global stockpile was created in 2013.[55] The International Coordinating Group for vaccine provision received 12 requests for vaccines between 2014 and 2015. Requests were made for 1.5million doses and 875,000 doses were shipped from the stockpile to a number of countries including South Sudan, Guinea, Haiti and The Democratic Republic of the Congo.[56]

Conclusions

Cholera continues to pose a public health threat in many countries where communities are exposed to large quantities of human excrement. Outbreaks are associated with high case fatality rates that can be lowered by appropriate fluid resuscitation. The prevention of cholera requires removing human excrement from the environment, especially the food and water supply. While expensive civil engineering solutions are currently unaffordable in communities at high risk, lower cost flexible decentralised water and wastewater treatment offers a potentially effective alternative. Low cost vaccines against cholera may be particularly useful in outbreaks if they are detected soon enough and the vaccine can be effectively deployed.

Conflict of interest

None declared.

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