

# Cholera in Yemen: Public health consequences of conflict

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Yemen is fighting a war on two fronts: a geopolitical conflict and a public health crisis, the worst cholera outbreak in history.<sup>1</sup> These two battles, however, represent two sides of the same coin. Cholera is an opportunistic infection that thrives in regions that lack proper sanitation.<sup>2,3</sup>

*Vibrio cholerae* colonizes the small intestine and secretes cholera toxin.<sup>4</sup> This toxin induces intraluminal chloride ion secretion and decreases the entry of sodium into enterocytes, leading to an electrolyte imbalance. Following a 12 to 72 hour incubation period, symptoms of diarrhea and vomiting appear, advancing to fluid losses of up to one liter per hour.<sup>4,6</sup> If left untreated, cholera can lead to dehydration, metabolic acidosis, and death.

As of April 2018, in Yemen, an estimated 19 million people lack access to safe water.<sup>7,8</sup> A World Health Organization (WHO) report dated 8 April 2018 details a cumulative total of 1,088,030 suspected cholera cases and 2,272 associated deaths.<sup>9</sup> To comprehend this avoidable death toll, we must appreciate both the state of Yemeni public health and the pathogenesis of cholera.

Fundamentally, the cholera outbreak in Yemen exists due to contaminated drinking water. This situation comes as a result of a sectarian conflict between the Saudi-led coalition and Houthi rebel forces now in its fourth year. While Yemen is one of the poorest countries in the Middle East, the destruction of sanitation facilities by Saudi-led coalition airstrikes, coupled with striking public sanitation workers, expedited the transmission of cholera.<sup>10</sup> Furthermore, in violation of international law, the Saudi-led coalition imposed a blockade on Yemeni seaports and the airport in Sana'a controlled by rival Houthi forces. Following international pressure, the coalition eased some restrictions in late 2017 and announced humanitarian aid packages for Yemen; however, a significant backlog of humanitarian supplies persists, exacerbating the country's crisis.<sup>11</sup> Since Yemen is fully dependent on the import of foreign medicines, these restrictions on commercial commodities have drained the nation of medical supplies and fuel. These fuel shortages experienced by domestic water companies lead to escalating costs of water trucking, an essential mode of clean water distribution.<sup>17</sup>

Approximately 2.2 million internally displaced persons reside in displacement camps with poor sanitation and waste management conditions.<sup>3,12</sup> Damage to infrastructure and hostility on the ground have resulted in only 45% of health care facilities in Yemen remaining in operation, with limited foreign engagement.<sup>13</sup> Specifically, four separate health facilities run by Médecins Sans Frontières (MSF) have been hit by airstrikes, with the bombing of Abs hospital on August 15, 2016 killing 19 people including an MSF staff member.<sup>14</sup> Consequently, efforts to control the spread of cholera, including the distribution of 1 million doses of cholera vaccine—half the global stockpile—by the WHO and the Global Task Force on Cholera Control (GTFCC)

partners, have been unsuccessful.<sup>2,15</sup>

One therapy in particular, oral rehydration solution, consisting of sodium, glucose, and safe drinking water, has proven effective in treating 80% of cholera cases.<sup>16</sup> Sodium-glucose linked transporter channels are spared by cholera and can be harnessed to co-transport glucose and sodium into enterocytes to equilibrate ion imbalances.<sup>17</sup> The establishment of dehydration centres in Yemen has had a moderate effect on reducing fatality to a low overall case-fatality rate of 0.25%.<sup>16,18</sup> The prevention and treatment of cholera is simple yet internal change and foreign intervention in Yemen are complicated by the conditions of war.

The WHO is currently working to implement a multi-sectoral intervention to manage the cholera outbreak and restore food, fuel, and medicines to Yemen.<sup>8,15</sup> In a zero sum game, these measures, including the systematic use of the oral cholera vaccine (OCV) for high-risk persons, have proven insufficient to effectively resolve the epidemic, with nearly 5000 cholera cases reported per day.<sup>15,18</sup> Concurrently, the WHO and partners continue to urge the Saudi-led coalition to find a political solution to the conflict and end all blockades on Yemen.<sup>1,19</sup> Although ongoing humanitarian intervention is paramount to preserve human dignity and life, only a political solution to this fighting will allow the Yemeni people to rebuild their broken country and prevent a new flashpoint for migration worldwide.

The WHO has foreshadowed future cholera outbreaks due to the explosive and unpredictable pathogenesis of the disease; nonetheless, the organization remains steadfast in their goal to eliminate cholera by 2030 through the Global Roadmap initiative that focuses on 47 countries that remain affected by cholera. The Yemeni outbreak has highlighted the need for targeted investments in infrastructure to improve water, sanitation, and hygiene, termed the WASH program, coupled with the use of OCV in the interim to control the transmission of disease in “hot spot” regions.<sup>15</sup> The operation consists of three axes: 1) early detection and rapid response through community-level surveillance; 2) a multi-sectoral approach to prevention in endemic countries through measures including the WASH campaign; and 3) improvement of coordination mechanisms for resource mobilization at the local and global levels.<sup>15</sup> These efforts represent a positive shift towards more proactive care, and may prove effective in the prevention of future large-scale outbreaks of cholera.

The cholera epidemic in Yemen highlights an Achilles heel of modern medicine: the dangerous influence of war on the spread of disease. In the face of advances in public health, the pernicious nature of war, with associated economic and infrastructure loss, incapacitates the provision of health services. It is the duty of the international community to hold adversarial groups accountable and develop diplomatic channels to facilitate the establishment of safe conditions for health workers in both conflict and post-conflict zones.

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