

Vibrio cholerae: Unravelling the threat of a global pathogen

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Dear Editor,

Vibrio cholerae is a Gram-negative bacterium that causes an acute infectious disease called cholera, characterized by severe vomiting and diarrhoea. Numerous cholera outbreaks have been recorded throughout mankind's history [1]. Although significant improvements have been made in public health and preventive medicine, cholera is still a major threat to the health of humans globally [2]. Regions with sub-standard infrastructure of water, sanitation, and hygiene (WASH) suffer the most from the adverse effects of cholera pandemics [3]. *V. cholerae* can navigate through the aquatic surroundings due to its single polar flagellum, contributing to its persistence in cholera-prone zones. It is also a rod-shaped and curved facultative anaerobe bacterium that thrives in freshwater and saltwater ecosystems, where it attaches itself to shellfish containing chitin [4].

V. cholerae leads a two-way mode of life; it can flourish within human hosts as well as in water bodies. The bacterium forms biofilms on plankton surfaces while in water. This increases its persistence in the environment [5]. It primarily spreads to humans through eating contaminated food or drinking inadequately treated water, especially in overcrowded living conditions and places with limited sanitation. Besides, environmental features, including nutrient availability, temperature, and salinity, can influence the proliferation of *V. cholerae* in aquatic sources [6]. Nonetheless, regions like Sub-Saharan Africa and South Asia are correlated with seasonally variable cholera outbreaks [7], recording high number of cases after monsoon rains when there is a prevalence of water contamination.

The human gut microbiome plays a significant role in both susceptibility to and defense against cholera [8]. This complex microbial ecosystem in the gut influences how the body responds to pathogens, and variations in the composition of the gut microbiome can impact the severity and outcomes of cholera infections [9]. Key areas of interest in understanding this role include the microbiome's protective functions, its influence on immune responses, and its interactions with *V. cholerae*.

A healthy and diverse gut microbiome can act as a natural barrier to *V. cholerae* colonization. Beneficial microbes like *Lactobacillus* and *Bifidobacterium* produce antimicrobial compounds and create a competitive environment that makes it more challenging for *V. cholerae* to establish itself [10]. Additionally, these microbes help maintain the gut's mucosal barrier, which further protects against pathogen invasion.

The gut microbiome has a strong influence on the host's immune response, which is crucial in cholera

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infection. A balanced microbiome can regulate immune pathways and promote the production of protective antibodies like Immunoglobulin A (IgA) in the gut [11]. These antibodies can neutralize cholera toxins and prevent the bacteria from adhering to the intestinal wall. Dysbiosis, or an imbalance in the microbiome, may weaken this immune defense, making individuals more susceptible to severe cholera symptoms.

Recent research suggests that a healthy gut microbiome may also enhance the effectiveness of cholera vaccines by supporting a more robust immune response [12]. Conversely, individuals with microbiome imbalances might have a reduced response to the vaccine, highlighting the microbiome's role in immunization outcomes. Overall, understanding the human gut microbiome's role in cholera provides valuable insights into preventive and therapeutic strategies, including the potential for microbiome-targeted interventions to reduce susceptibility to cholera and improve treatment outcomes [13].

New approaches and therapies, as well as ongoing efforts, focus on sustainable solutions, leveraging technology, community-driven programs, and innovative treatment options. Key strategies include climate-resilient infrastructure, microbiome-based therapies, digital tools for monitoring, and novel sanitation technologies. Additionally, probiotic supplements and microbiome-targeted treatments are being explored as protective measures against waterborne pathogens [14]. Specific probiotic strains may help improve gut health and reduce the severity of diarrheal diseases, offering an accessible therapy that supports immune defense in vulnerable communities [15]. Furthermore, research into edible vaccines that use genetically modified plants to express antigens for diseases like cholera is underway [16]. These vaccines could offer an accessible, cost-effective alternative for populations with limited access to traditional immunization services [17].

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