

WATER AND HEALTH

Why cholera is ‘pretty damn smart’ and how we can beat it

The recent cholera outbreak in South Africa has brought back attention to this waterborne disease. Three experts share their views. Matthew Hattingh reports.



The precise origin of the cholera and the exact strain of the toxin-producing bacteria that has claimed 47 lives this year, mostly in Hammanskraal near Pretoria, remains a lot like the polluted waters of the region's Apies River, murky. What is clear, however, is that the loss of life could have been avoided. Ensuring drinking water safety is the key to beating the infectious diarrhoeal disease, but to get this right we will need to do two things: hold officials and politicians to account over our dilapidated or non-existent wastewater treatment systems; and press into service more cheap-and-cheerful, household-based water treatment systems.

These were a few of the views and recommendations that emerged during an online seminar hosted by the Academy of Science of South Africa, aimed at improving understanding

of the disease and finding ways to curb it. Prof Jerome Singh, principal investigator for the Academy's Scientific Advisory Group on Emergencies, told the 14 August webinar that urgent steps were needed if we were to avoid more Hammanskraals.

The advisory group, which brings together scientists from across the country, identified some of the causes of the current outbreak – which started in mid-April before tapering in mid-June – and suggested measures to put things right. Singh said Hammanskraal was “symptomatic of a widening collapse of wastewater treatment facilities almost nationwide”, which was increasingly affecting even big, well-resourced cities. And he warned that unless action was taken against mismanagement, the collapse would “continue to unfold, precipitating multiple, concurrent human health and environmental emergencies”.

An international expert on law, ethics and public health, Singh said South Africa's water sector was "beset by multiple challenges". He mentioned incompetent leadership; apathy; a lack of maintenance and the necessary skills for this at existing treatment plants (exacerbated by people retiring or quitting); and a failure to build new plants to meet the needs of our growing population.

Funding for this work was in short supply, but was being squandered, he said, criticising the spending of public money on "issues that are really not important when we should be dedicating it to bread-and-butter issues at a local government level". Meanwhile, citizens who can't or won't pay for services, and vandalism compounded matters.

How do we improve skill levels? Singh called for initiatives to build capacity. He also suggested we look at how top graduates, especially engineers, might be enticed to "work in rural municipalities to make sure their water treatment plants work, and so that people don't get cholera". He further called on the departments of Water and Sanitation, and Cooperative Governance and Traditional Affairs, the South African Local Government Association and municipalities to work together to promote governance and to "urgently engage" with water services providers.

Singh endorsed measures for training and equitable water pricing, but said this would need Cabinet-level political support. He called for governance and legislative reform and measures to increase "transparency, accountability, competence, and operational efficiency". He added that, "There doesn't seem to be anything that is done towards services officials when they fail to act, when they fail to ensure that basic maintenance is done, or they fail to take into account a five- or 10-year plan to take into account the increase in population."

The Auditor-General and others had been flagging problem areas for years, but there had been no consequences for the officials implicated and this needed to change. "If people are dying, and this is as a result of direct negligence, where it is foreseeable that this is going to happen, people need to face disciplinary action and where applicable, criminal charges. Because unless you have an accountable system, you're going to have continued cholera outbreaks and continue deaths when this is a very, very preventable and avoidable situation."

Singh wanted to see citizens educated so they know their rights — and know what should be expected of public officials. At the same time, measures were needed to encourage people to safeguard infrastructure and to "promote responsible stewardship of water and wastewater management". He called for a campaign to foster a "deep reverence" for water across the country, including in informal settlements where pollution and sanitation problems abound. Surveillance must be improved too, so outbreaks could be detected earlier, saving lives. There had been a "lot of exciting science" and technological developments, including around no-flush toilets and decentralised treatment systems, and Singh called for funding for more research and innovations.

Innovations, particularly on-site and decentralised solutions, held great promise in the fight against cholera, medical microbiologist

Prof Eugene Cloete told the webinar. Cloete, who is CE of the Cape Higher Education Consortium, shared an excerpt from a 1996 World Health Organisation fact sheet that identified the provision of safe drinking water and the proper disposal of human excreta as trumping all other interventions when it came to public health and national development. But he stressed that ensuring the safety of drinking water was "the most important thing" for preventing cholera.

To underline this point, Cloete, shared findings of a study on the 2000-2004 cholera outbreak in KwaZulu-Natal, which by March 2004 had resulted in 575 deaths. The study found that cases of cholera correlated strongly with a lack of potable water rather than with a lack of sanitation. In one, far northern region of the province, for example, where the bucket system was commonplace, no cases of cholera were reported, whereas in other areas where sanitation was considerably better, many cases of cholera were reported.

"If we want to make sure people do not get cholera, the number one thing we have to do is to provide safe drinking water," he said. But how do we do this where people are isolated? How do we reach the 300-million people in Africa who lack access to safe drinking water and who live in places where it's hard to pipe water to? Cloete said that in municipal areas water safety plans (which were readily available) must be followed. For rural areas he advocated "empowering people at the point of use" by equipping them with appropriate technology.

He briefed the webinar on a Water Research Commission-funded project which harvested rainwater from shack rooftops. Cheap solar heaters were then used to pasteurise the water (an idea borrowed from the dairy industry). Provided the water was heated to 80°C and above for more than a minute, it was found to kill all microbial pathogens. What's more, the system was gravity fed, so required no electricity and was expected to last for more than 25 years with only minimal maintenance.

He said individual systems could provide 800-1 000 litres of water a day, making it ideal for villages, clinics, hospitals, schools and orphanages. "It brings water to people in a safe way at a very low cost," Cloete added, mentioning a per capita cost of R3.70 per person, per year.

An even simpler and cheaper approach involved putting rain or river water into half-blackened plastic bottles and disinfecting it by exposing it to sunlight. The method was "pretty effective" in providing potable water using ultraviolet irradiation, "but not as effective as heating the water to temperatures of 90°C-plus", he said.

Chemical treatment of water, including using household bleach, was another option, particularly in emergencies, but Cloete cautioned that this came with costs and complications, including getting the dosage right. Like Singh, Cloete stressed the importance of surveillance in controlling cholera outbreaks and he questioned to what extent it was up to scratch, suggesting that if we improved surveillance we might find cholera has been under-reported.

What about using vaccines to deal with cholera outbreaks? Prof Nicola Page, principal medical scientist with the National Institute

for Communicable Diseases, said there was some debate among experts, with the general view being that vaccines were more useful for “really big outbreaks where you want to prevent them from spreading further” or “where providing clean water or treating water wasn’t sufficient”.

This was because it takes time to procure vaccines and roll them out, by which time (as was the case with the current outbreak), the disease may already be on the wane. She said other African countries have used the vaccine for much bigger, less localised outbreaks than Hammanskraal.

Three vaccine formulations have been developed with one licensed in South Africa. The vaccine must be kept cold (complicating matters) and given in two doses, 10 days apart, with efficacy kicking in after eight days after the second dose. The vaccine remained 85% effective after 12 months, tailing off to 50% over two years. Boosters were needed to sustain immunity. For children under six, the vaccine offered less protection, with immunity waning after six months.

On the plus side, the vaccine was cost effective, safe, easy to administer and built herd immunity.

Page provided the webinar with a lively overview of the *Vibrio cholerae* bacteria, some of the different strains, serogroups, serotypes, biotypes and variants of these; how these developed; how they worked; and how they were transmitted.

Vibrio (from the Latin for quiver) bacterium, evolved or mutated over time to be capable of surmounting the formidable defences the human body erected in its path, she explained.

Once ingested, it must adjust rapidly to the hostile conditions of the human gut. “They put out this protein arsenal to help them get through the acid of the stomach. Despite these proteins, only a few vibrios actually reach the small intestine. And this is probably why the infectious dose is quite high.”

But assuming cholera bacteria do make it through to the small intestines in sufficient numbers, “their job is not over.” They have to cope with additional antimicrobial agents, things like bile salts and antimicrobial peptides.”

Next, they must penetrate the intestine’s internal mucus layer to reach the epithelial (intestinal tissue) cell surface. This is some feat, when you consider that the layer is 100 to 400 times thicker than the length of a cholera bacterium. That the cholera can manage this epic journey was thanks to the mucin enzymes it produced, plus their “wonderful polar flagella”, the tail-like appendage which helped them burrow through.

“In addition to this, if they don’t have enough to worry about, they have to overcome colonisation from other gut microbiota. And they do this by activating a type six secretion system. This basically operates as a molecular syringe that kills bacterial competitors when they come into contact with the cholera bacteria,” said Page.

“So I think they’re pretty damn smart,” she said with an infectious enthusiasm for the topic.

Once through and attached to the intestinal epithelial cells, the cholera starts multiplying, forming micro-colonies and expressing toxins which are taken up by the cells, impairing their function and resulting in a massive release of electrolytes and water. This leads to the diarrhoea characteristic of the disease.

With *Vibrio* now reaching a high cell density and nutrient levels in the intestine decreasing, “the bacteria know it’s time to leave the party”. Some detach from the epithelial surface and escape in the faeces. Page said that individuals who have not received effective antibiotic treatment can shed *vibrio* for up to 10 days after infection, “releasing the bacteria into the environment and increasing the risk of further infections downstream”.

Treatment is relatively easy and successful for most people, but time was of the essence.

“If we can get people rehydrated promptly, they usually survive,” said Page, adding that this might mean 6-litres of fluids in the case of moderately dehydrated adults. But severely dehydrated individuals were at a risk of shock and required rapid administration of intravenous fluids. Antibiotics can help too.

In response to a question about the source of the Hammanskraal outbreak, Page said although the water tested did not meet standards, only one sample (from a tap) detected strains of disease-causing cholera bacteria. “But just because we didn’t find it, doesn’t mean it wasn’t there. I am not sure we will ever really know what the source was. But the fact that the water was bad probably didn’t help matters at all.”

Water Research Commission research manager Dr Eunice Ubomba-Jaswa, a medical microbiologist and research manager with the Water Research Commission, moderated the webinar. A recording of it can be viewed at <https://youtu.be/AI-0wFenwuw>.



SIDS

President Cyril Ramaphosa with officials from the Department of Water and Sanitation and the City of Tshwane at the Rooiwal Wastewater Treatment Works outside Hammanskraal in June this year. The malfunctioning of the treatment plant has been cited as a potential factor for the outbreak of cholera in the area.