Virus hunter: Environmental surveillance and the polio endgame

The world is on the brink of eradicating polio, thanks in part to decades of intensive vaccination programs led by the World Health Organization (WHO), the Bill & Melinda Gates Foundation, the United Nations Children's Fund, Rotary International, and Gavi, the Vaccine Alliance. However, complete eradication is, in part, dependent upon our ability to rapidly find and eliminate rare and hidden pockets of disease before they can spread further.

Both wild poliovirus type 1 (WPV1) and vaccine-derived polioviruses (VDPVs) can spread silently and go undetected for weeks or even months before communities see any symptomatic patients. Environmental surveillance (ES) can identify where and when diseases like polio, and other viruses including SARS-CoV-2, might be hiding before outbreaks occur. A sensitive ES system can trigger health systems to begin vaccination campaigns to prevent outbreaks before clinical cases emerge.

New environmental surveillance tool

PATH and the University of Washington (UW) have developed, validated, and commercialized an ES tool to assist in the global eradication of poliovirus (PV). The bag-mediated filtration system (BMFS) collects wastewater in a bag and then passes it by gravity through a simple filter that specifically binds viruses. The BMFS can process volumes of up to 6 liters of wastewater. It offers higher sensitivity sampling large volumes of wastewater utilizing a small filter that is easily shipped from remote and challenging environments. The use of preservatives on the filter reduces the need for immediate processing when the filters are received at the laboratory.

Field validation

It is critical to evaluate and optimize the surveillance tools and methods utilized in the effort to eradicate PV from an area or population. PATH and the UW assessed the BMFS in field settings and refined it to make it more effective, easier to use, and simpler to manufacture. Field evaluations in Kenya, in collaboration with the Kenya Medical Research Institute, informed changes to the kit design, development of protocols, and streamlining of sample collection and shipping procedures.[1] The BMFS was subsequently validated by the Pakistan Polio Eradication Programme (National Institute of Health and WHO Pakistan), where it demonstrated high sensitivity.[2] User inputs from the Pakistan teams led to further improvements to the collection bag to simplify its design and improve collection from fast-flowing waste streams. Additional operational research has been conducted in Bangladesh, Haiti, India, Mexico, and Zimbabwe. Ensuring commercial access is a critical step in translating the BMFS into a globally available tool to support PV surveillance and eradication programs. PATH has selected Scientific Methods Inc. as the commercial partner to supply BMFS kits at acceptable pricing to countries where PV remains active. The WHO Global Polio Laboratory Network has approved the BMFS and has confidence in the data generated by its use.

The BMFS filters efficiently capture polio and other enteric viruses from wastewater. Photo: UW/Christine Fagnant-Sperati.

ES is particularly important in the two countries where WPV1 remains endemic. Afghanistan and Pakistan are now the primary focus of eradication programs, with two major factors challenging this effort:

1. WPV1 can be reintroduced from these endemic regions to other areas where immunization coverage

has been insufficient (e.g., the Horn of Africa and Central Africa).

2. The Sabin strains of PV used in the production of oral PV vaccine are live attenuated (or weakened) viruses. These strains replicate in the vaccinated host and can be spread to unvaccinated individuals. While a benefit to increasing overall herd immunity, in rare circumstances, over time, the attenuated virus can revert to being virulent and cause disease in the unvaccinated. These VDPVs are essentially as dangerous as WPV1 and are the common cause of outbreaks in nonendemic countries with limited immunization coverage.

The current methods to detect PV from ES samples require qualified reference laboratories, which are often far from the remote and challenging regions where WPV1 remains endemic, requiring that liquid samples be shipped long distances under cold chain to preserve the contents. Due to the high cost of cold chain transport and potential biohazards these samples present, the volume of samples for PV testing is limited. As a result, this method can have reduced sensitivity due to the relatively smaller sample volumes processed. To assist in the final push for global eradication, additional supporting ES tools are needed to monitor populations for the presence of WPV1 and VDPVs.

Next steps

The BMFS may support ES for other pathogenic enteric viruses, such as rotavirus, which, like PV, can persist in the environment for extended periods, with similar advantages for biosafety, large sampling volume, and ease of use. An initial assessment in Kenya demonstrated the effectiveness of the BMFS in recovery of a variety of enteric viruses.[3] In addition, a new field of critical interest includes implementation of the BMFS for SARS-CoV-2 detection to assess its persistence and distribution within communities to inform on asymptomatic reservoirs as transmission risks.

More recently, PATH, in collaboration with the WHO Regional Office for the Eastern Mediterranean and in-country partners in Pakistan and Yemen, is scaling the usage of the BMFS to additional new sites. These efforts are intended to provide further ES data to better track the prevalence of both WPV1 and VDPVs or confirm that the virus is absent from these communities.

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Two polio surveillance staff walk alongside a creek where the performance of the BMFS was assessed. Photo: UW/Christine Fagnant-Sperati.

For more information

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