Detecting poliovirus hiding in the environment

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, UNICEF, and Rotary International. However, complete eradication is, in part, dependent on our ability to rapidly find and eliminate hidden pockets of disease.

By the time communities see symptoms in patients, wild poliovirus (WPV) and/or vaccine derived polio virus (VDPV) may have been circulating silently and undetected for weeks, or even months. Environmental surveillance (ES) can identify where and when diseases like polio, and other enteric viruses, including SARS-CoV-2, might be hiding. A sensitive ES system can trigger the health system to begin vaccination campaigns before clinical cases emerge.

New environmental surveillance tool

PATH and our key development partner, the University of Washington (UW), have developed, validated, and commercialized a new 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 binds the PV. The BMFS can sample volumes of up to 6 liters of wastewater. It offers higher sensitivity as it samples a large volume, and the small filters are easier to ship from remote and challenging environments than liquid samples. Furthermore, the use of preservatives on the filter reduces the need for immediate processing when the filters are received at a reference laboratory.

Field validation

In order to confirm the eradication of PV from an area or population, it is critical to first evaluate and optimize the surveillance tools and methods utilized in this effort. PATH and the UW assessed the BMFS in field settings and refined it to make it disposable, easier to use, and less expensive 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 improved BMFS design was validated by the Pakistan Polio Eradication Programme (National Institute of Health and WHO Pakistan), where it demonstrated high sensitivity[2]. Bangladesh and India conducted additional operational research. The newer design was supplemented with revised laboratory protocols that included switching to a more simple and rapid secondary concentration method to improve throughput of laboratory processing. The new concentration method is faster, is less labor intensive, and takes only a few hours, instead of an overnight step, to prepare samples for testing. Ensuring commercial access is a critical step in translating the BMFS into a globally available tool to support PV surveillance and eradication programs. PATH selected Scientific Methods Incorporated (www.scientificmethods.com/) as the commercial partner to supply kits at acceptable pricing to countries where PV remains active.

The BMFS captures traces of the poliovirus in wastewater. Photo: UW/Christine Fagnant-Sperati.

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

1. WPV can be reintroduced from the remaining 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 nonvaccinated individuals. This had been viewed as a benefit in that it increases overall herd immunity, but the risk of this strategy is that over time the attenuated virus can revert to being virulent and then cause disease in the unvaccinated. These VDPVs are effectively as dangerous as WPV, and VDPVs are a common cause of outbreaks in nonendemic countries today.

The current ES methods to detect PV from environmental samples requires highly skilled reference laboratories. These laboratories are often far from the remote and challenging regions where WPV is endemic, requiring liquid samples to be shipped over long distances under cold chain to preserve the contents. Due to the high cost of transport and potential biohazards the samples present, the volume of samples that can be tested and the frequency of ES sampling that can take place are limited. As a result, this method suffers from reduced sensitivity due to the relatively small sample volumes that are processed, and lower throughput by the longer time required for sample preparation. To assist in the final push for global eradication, additional supporting ES tools are needed to monitor populations for the presence of WPV and VDPV.

Next steps

Similar to PV, other enteric viruses can persist in the environment for extended periods of time. Tools like the BMFS can also support ES for these viruses, with similar advantages for biosafety, sampling volume, and ease of use. Initial assessment demonstrating the effectiveness of the BMFS for detection of enteric viruses has been completed[3]. A new field of critical interest includes the implementation of the BMFS for SARS-CoV-2 virus detection to assess its persistence and distribution within communities to inform on asymptomatic reservoirs as transmission risks.

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For more information

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