ENVIRONMENTAL SURVEILLANCE FOOTPRINT IN THE AFRICAN REGION, 2024.

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ABSTRACT: *The gold standard for poliovirus detection in the Global Polio Eradication Initiative (GPEI) is the Acute Flaccid Paralysis (AFP) surveillance. Environmental Surveillance (ES) complements AFP surveillance. Environmental Surveillance is the regular collection of sewage or wastewater that is contaminated with human faecal matter and testing the sample in the laboratory for the presence of poliovirus. The African region first initiated ES in 2011 in Nigeria and by December 2024, a total of 46 of the 47 countries in the region have initiated ES. The anticipated eradication of polio in the next few years brings to the fore the imperative of enhancing polio surveillance, and especially ES. It is therefore imperative for the region to ensure adequate ES footprint, especially in polio high-risk areas and sustain ES site sensitivity for timely detection of poliovirus transmission to enable prompt response. The regional polio laboratory network should be capacitated to accommodate ES expansion. In addition, ES has the potential to be upgraded to detect other pathogens of public health significance.*

KEYWORDS: Environmental Surveillance, African region, Pathogens, Polio laboratory, Poliovirus.

INTRODUCTION

The African region was certified Wild Poliovirus (WPV) free by the African Regional Certification Commission (ARCC) for poliovirus eradication in August 2020 [1-3]. However, in 2021 and 2022, the region experienced WPV importation of a virus strain circulating in Pakistan involving two countries, Malawi and Mozambique [4,5]. These importation-related WPV outbreaks were declared closed after a detailed investigation by the independent polio Outbreak Response Assessment (OBRA) team in May 2024 [6]. The work of polio eradication in the region is yet to be completed considering threats of WPV importations from the remaining polio-endemic countries (Afghanistan and Pakistan), persistent transmission of circulating Vaccine Derived Poliovirus (cVDPV), population dynamics and low population immunity [7-9].

Disease surveillance is the systematic collection and analysis of data, and is an essential tool for the planning, implementation, and evaluation of national and international disease prevention and control policies and programs [10,11]. The AFP surveillance is the gold standard for poliovirus detection, and with the support of the Global Polio Laboratory Network (GPLN), it ensures effective monitoring of poliovirus transmission [12-14].

Environmental Surveillance, also referred to as wastewater-based epidemiology (WBE) or wastewater and environmental surveillance (WES), is the regular collection of sewage or wastewater that is contaminated with human faecal matter and analysing the sample in the laboratory for the presence of poliovirus. Other pathogens, chemicals and anti-microbial resistance (AMR) genes can also be detected through ES [15-18]. Environmental Surveillance complements AFP surveillance and is more sensitive than AFP surveillance under optimal conditions, as it detects infectious diseases among asymptomatic, pre-symptomatic, symptomatic, and post-symptomatic individuals [19-21]. The rationale for ES is that all polio-infected persons regardless of symptoms continue to excrete the virus in the stool for a period of 6 to 8 weeks; and that the virus survives in the environment for a period dependent on environmental conditions [22,23] Traditional surveillance for most diseases including polio is dependent on access to healthcare systems, health seeking behaviour and remains logistically difficult, costly, and inequitable. Environmental surveillance, on the other hand, is relatively low cost, faster, non-invasive, unbiased, anonymous, not dependent on access or health-seeking behavior and is scalable to detect other pathogens of public health significance [24-26]. However, despite these advantages, ES has been utilized in the region mainly for polio surveillance, especially prior to the COVID-19 pandemic [27-29].

Overview of Environmental Surveillance

The history of modern ES can be traced to the Broad Street cholera outbreak in 1854, in which John Snow demonstrated through mapping and data analysis that the deadly disease was spread when people drank contaminated water [30]. Later in 1928 and 1932, typhoid and polio organisms were isolated from sewage, respectively [31,32]. Pathogens enter wastewater through multiple routes, including stool, urine, saliva, vomitus, respiratory secretions, skin, and blood. These pathogens can be monitored for early detection of outbreaks and for evaluating the impact of interventions [33]. Environmental Surveillance for polio is arguably the most widely known application of wastewater-based epidemiology. However, the advent of the COVID-19 pandemic has promoted the use of ES further as a powerful tool to monitor the

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spread of the virus and its variants in the community in near real time [34-36]. In addition, ES has recently been used to monitor Zika virus and mpox outbreaks [37-40]

Despite its advantages, ES suffers a setback in that it can only be implemented where suitable sites exist in eligible high-risk areas and where representative samples from significant draining populations can be collected. ES is also dependent on the availability of adequate field logistics and laboratory services [41]. A reliable estimate or prediction of the number of infected individuals in a community based on viral detection is still not possible. In addition, ES sensitivity is dependent on such factors as population of shedders, duration of shedding, dilution and impact of chemicals and other toxic substances on the target pathogens [42].

Environmental Surveillance Footprint in the African Region

In 2024, about 73 countries routinely report to the WHO on the performance of their collective 1141 ES sites. Environmental Surveillance for polio was started in the WHO African region in Nigeria in 2011, and with gradual expansion, by December 2024, the number of ES implementing countries was 46 out of the 47 countries in the region. The only country yet to initiate ES is the Comoros due to the unavailability of suitable ES sites. The latest country in the region to initiate ES is Eritrea (July 2024). The total number of ES sites in the 46 ES implementing countries is 534. Most (347) of the sites are open community drains, while the rest are wastewater treatment plants (WWTPs). The number of sample collection sites per country ranges from 2 (Mauritania) to 135 (Nigeria). The number of provinces and districts with at least one ES site is 244(38%) and 371(8%), respectively. The proportion of sites in high-risk provinces is 90% and at least 400(30%) million people live in provinces with at least one ES site.

All the sites use the grab method of sample collection as recommended by the WHO [43]. The Grab method of sampling is more quantitative and allows an estimation of detection sensitivity [44]. All 16 polio laboratories in the region are analyzing AFP and ES samples. The last laboratory to initiate ES sample analysis was the polio laboratory in Zimbabwe (2024).

Efforts are ongoing with the support of the Gates Foundation to optimize ES in the region through the expansion of ES, enhancing the quality of sites, improving the capacity of personnel, and improving the timeliness of sample shipment, as well as promoting the use of electronic data tools for ES. The ES optimization efforts started in earnest in 2022, and by the end of 2024, a total of 58 optimization missions to 46 countries in the region were conducted. These missions resulted in the initiation of ES in 12 countries and the expansion of ES sites in the other countries. The number of new ES sites created and underperforming ES sites closed during the optimization missions was 156 and 174, respectively. Most reasons for ES site closure are related to underperformance (<50% enterovirus isolation and especially zero enterovirus isolation). Other reasons for site closure include dry site, Site blockage (refuse, road construction), chemical contamination, and restricted access due to security or physical barrier. The main indicator of ES site sensitivity is the isolation of enteroviruses [45, 46]. A site is considered sensitive when enteroviruses (EV), including poliovirus, are detected in at least 50% of samples, and at least 80% of ES sites in any country are expected to meet this indicator. The sensitivity of ES sites in the region varies significantly. Closed and open drainage systems have varying sensitivities. Closed systems, like WWTPs or piped sewage networks, are generally more sensitive due to high yield of concentrated sewage, higher draining population and less prone to exposure to the environmental elements, including

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chemicals, dilution and dispersion of the virus [47]. The selection of open drains as sampling sites is difficult, especially during the rainy season when the draining wastewater is diluted. Here, the focus is on selecting ES sites in densely populated slum areas and other high-risk areas. In addition, sample handling (transport and storage) and processing in the laboratory also affect the sensitivity of the ES.

Key challenges to implementing Environmental Surveillance in the African Region

One of the main challenges impacting ES in the region is the paucity and skewed distribution of WWTPs [48, 49]. Most of the WWTPs are located in urban areas in the East and Southern sub-regions, while the Western and Central sub-regions have a comparatively limited number of such closed systems thus accounting for the difference in the quality of ES sites in these areas. Many of the high-risk areas lack suitable sites (either open or closed systems), especially in rural settings.

Environmental surveillance is a cost-effective monitoring system and, therefore, sustainable. It is also scalable to monitor other pathogens and markers beyond polio to offer early warning insights for decision making, disease preparedness, prevention and control. However, despite these advantages, there is suboptimal ownership and investment to support ES [50].

It has been estimated that for the African region to have an optimal ES footprint in all the high-risk areas, an additional 500 ES sites will need to be created. However, the current polio laboratory capacity of 700 ES samples/month can only accommodate an additional 150 ES sites. Thus, further investment in improving laboratory capacity is needed to support an optimal ES footprint.

The existing gaps in the conventional surveillance system, the need to have an effective early warning surveillance system to enable timely pandemic preparedness and response, have propelled the use of ES as a form of early warning system for infectious disease detection. Despite the proven high sensitivity of ES in the detection of targeted pathogens, implementation of ES in the region to date is mostly restricted to monitoring of a single pathogen (poliovirus) or small numbers of pathogens during ‘opportunistic’ studies. However, the inclusion of other pathogens of public health importance (those with epidemic and pandemic potential as well as those that represent ongoing risks to society) is imperative. Environmental Surveillance can be used to detect other pathogens, including hepatitis A, Measles, and other respiratory viruses such as Influenza and SARS-CoV-2 (51).

CONCLUSION

Environmental Surveillance has proven to be a sensitive and complementary strategy to AFP surveillance, and has the potential to provide additional information on other pathogens of public health significance to support epidemic and pandemic preparedness, decision-making and timely response. To achieve an optimal ES footprint in the region, there is a need to have a commensurate improvement in the capacity of polio laboratories to accommodate further ES expansion. Sustainability issues, including ownership, provision of necessary wastewater infrastructure and use of appropriate technologies, will also go a long way in strengthening ES in the region.

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TT: Writing – original draft. Visualisation, charts.

DY: Writing – original draft, visualisation, charts.

OS: Writing – original draft.

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Conflict of interest

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APPENDIX

Figure 1. Map showing high-risk provinces and provinces with Environmental Surveillance sites in the African Region, 2024

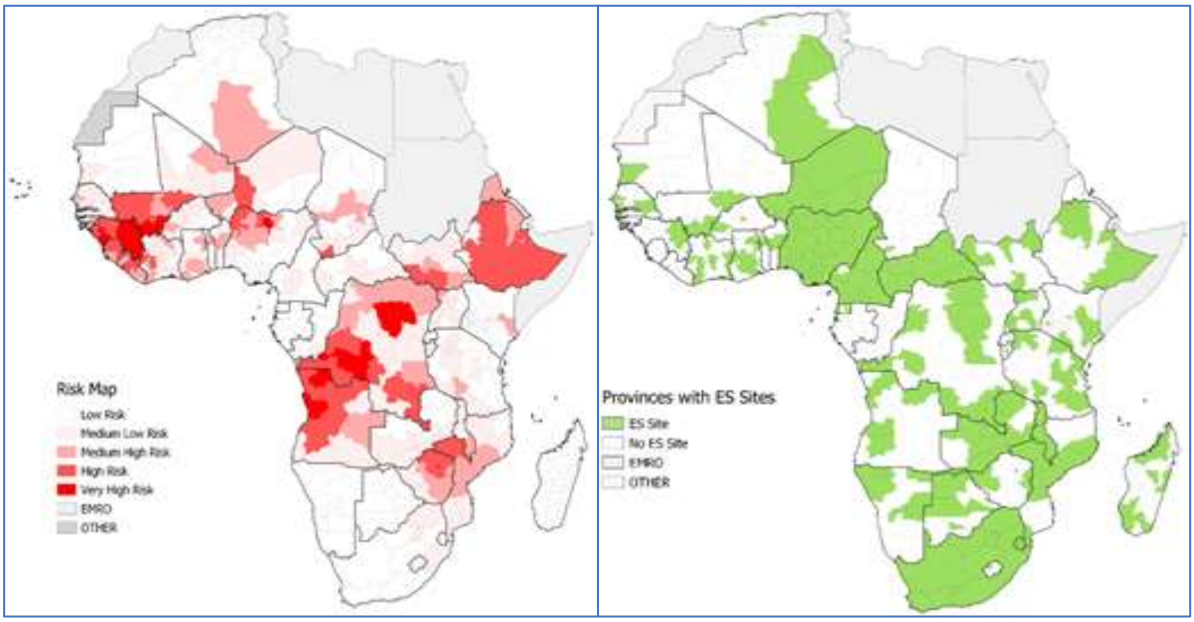
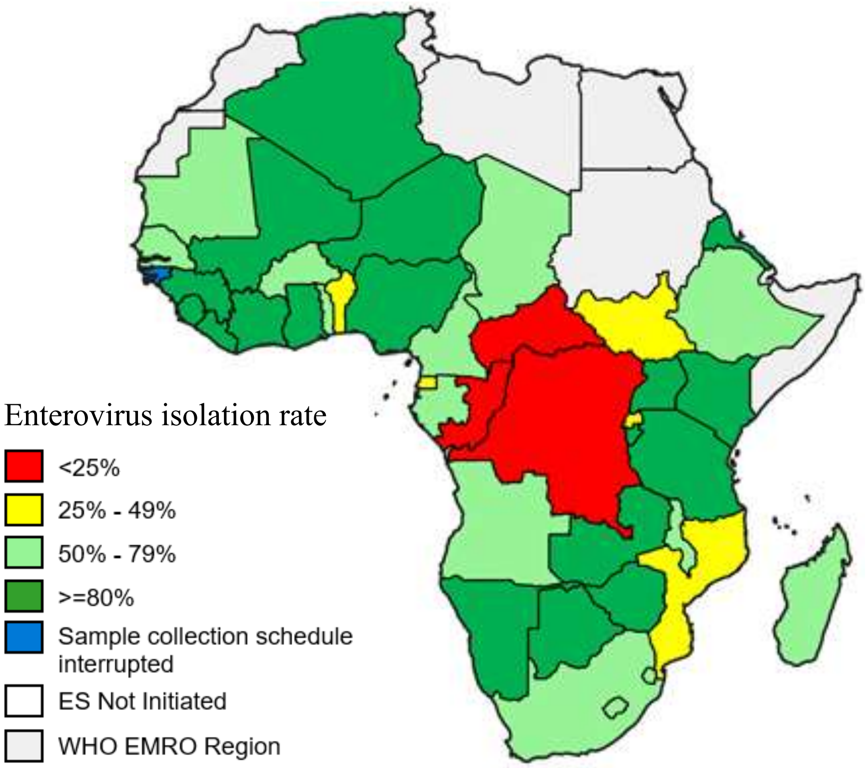


Figure 2. Map showing the sensitivity of Environmental Surveillance sites in countries implementing Environmental Surveillance, 2024.



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