

The challenges of poliovirus eradication

Abstract

Following the successful efforts to wipe out the virus of Smallpox (Variola virus) that started in the 1950s and officially realized their goal in 1980, the World Health Organization (WHO) made a commitment in 1988 to eradicate Poliovirus and poliomyelitis and achieve a Polio-free world by 2000. This ambitious project proved to be much more challenging than initially anticipated. While many of its objectives have been met (including the effective eradication of one of Poliovirus antigenic types from human populations) and the virus has been eliminated from the vast majority of countries around the globe, there is still work to do to complete this mission. The remaining challenges are intimately associated to the very nature of the actors involved in this enduring game: the

Poliovirus itself, the vaccines at hand, and the human factor. These are briefly reviewed here.

Introduction

The global efforts to control and eradicate Poliovirus and poliomyelitis worldwide reflect on many aspects humanity's long history of tragedies and triumphs, scientific successes and failures. Paralytic poliomyelitis, one of the most crippling manifestation of Poliovirus infection, is arguably one of the oldest viral disease associated with human civilizations, with evidences of the infection found in some 3000-year old Egyptian mummies.

While Poliovirus and poliomyelitis have been along for ages, the virus took center stage in the early 1900s, when annual epidemics of poliomyelitis affected millions of children around the globe. In the United States, regular waves of viral infections occurred annually until the development of the first vaccine in the 1950s.^{1,2}

Following the successful efforts to wipe out the virus of Smallpox (Variola virus) that started in the 1950s and officially realized their goal in 1980³ the World Health Organization (WHO) made a commitment in 1988 to eradicate Poliovirus and poliomyelitis and achieve a Polio-free world by 2000. This ambitious project proved to be much more challenging than initially anticipated. While many of its objectives have been met (including the effective eradication of one of Poliovirus antigenic types from human populations) and the virus has been eliminated from the vast majority of countries around the globe, there is still work to do to complete this mission. The remaining challenges are intimately associated to the very nature of the actors involved in this enduring game: the Poliovirus itself, the vaccines at hand, and the human factor. These are briefly reviewed here.

Poliovirus

Polioviruses consist in three distinct viral strains or antigenic types designated Poliovirus type 1, 2 and 3. All three serotypes must be eradicated. These viruses can survive extreme environments such as the highly acidic conditions of the gastrointestinal tract and among the three strains, Poliovirus type 1 is responsible for most cases (79%)¹ of paralytic poliomyelitis. Like other RNA viruses, Polioviruses has a high rate of mutation and can recombine quite easily, causing headaches for vaccine strategists. While the good news is that Poliovirus receptor is only expressed on cells of humans and a few subhuman primate species, with no known animal reservoirs, viral infection in humans is often asymptomatic and can go undetected. After replicating in the gastrointestinal tract, the virus can produce viremia and occasionally, reach the central nervous system where

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it destroys lower motor neurons, causing a typical flaccid paralysis without permanent sensory loss. About 1 in 150 primary Poliovirus infections results in paralytic poliomyelitis.¹ These peculiarities make Poliovirus a very tough and resilient adversary.

Poliovirus vaccines

The first Poliovirus vaccine was approved for use in the US and then on a wider scale after an extensive clinical trial conducted in 1954 and involving hundreds of thousands of children.⁴ This vaccine, the so-called Salk vaccine, is essentially a suspension of purified, chemically inactivated Poliovirus particles. The Salk vaccine was quickly followed by the Sabin vaccine, a suspension made from purified, live-attenuated Poliovirus virions.⁵ Both inactivated and live Poliovirus vaccines, traditionally made with the three viral serotypes mixed together (trivalent), have their strengths and weaknesses. While the inactivated vaccine is characterized by its safety and stability, it is not as immunogenic as its live-attenuated counterpart. On the other hand, the live-attenuated vaccine elicits a strong immune response in its recipients, but it is to some extent unstable genetically and can be problematic in people with immune deficiencies. Nevertheless, together these two vaccines have revolutionized the Poliovirus landscape and led to remarkable achievements in the elimination of the infection worldwide, including the effective eradication of Poliovirus type 2 in human populations.

In recent years, vaccine strategists have been forced to review their approach to Poliovirus eradication. One reason has been the disappearance of Poliovirus type 2. Another issue that came to light was related to the nature of the Sabin vaccine itself. Because the attenuated virus in the Sabin vaccine replicates harmlessly in vaccinated subjects, it is released in stools and can be found in the environment. Cases of re-infection by the vaccine strains of Poliovirus have been documented. Even worse, in rare cases the virus in the vaccine was found to revert to the wild-type, pathogenic virus through mutation and/or genetic recombination, with re-acquired neurovirulence and capacity to circulate.⁶

Novel vaccines and strategies to circumvent these problems are being developed and some have already been introduced such as new monovalent and bivalent oral poliovirus vaccines,⁷ along with inactivated Poliovirus vaccines derived from the attenuated Sabin strains. According to most experts, achieving a polio-free world will eventually require stopping routine immunization with oral Poliovirus vaccines and use of inactivated vaccines.

Human nature

One of the most difficult remaining tasks in the elimination of Poliovirus globally has to do with humans themselves. Misinformation and ignorance, fear and suspicion, politics and money, regional armed conflicts, all contribute to make the few lasting steps of an already long and arduous process a real challenge. Among the few remaining spots struggling with cases of Poliovirus, Pakistan and Afghanistan are two countries where polio has never been stopped. In countries ravaged by wars, Poliovirus control remains a major challenge. Sadly, many dedicated health workers and volunteers have lost their lives while conducting vaccination campaigns in these areas. Innocent children should not be the victims of these conflicts and suffer because of the interruption of critical vaccination programs.

On a positive note, in July 2016, Nigeria marked two years since its last case of wild Poliovirus. Currently, Afghanistan and Pakistan are the only two remaining endemic countries. So far in 2016, Afghanistan has reported 6 cases of infection and Pakistan, 13. As of July 27, the number of cases of wild-type Poliovirus infection reported globally was 19 and consisted essentially of Poliovirus type 1.⁸

We may have missed our primary goal to eradicate Poliovirus by 2000. However, we are now closer than ever to reach our objective. To achieve Poliovirus eradication, sustained political and financial commitments are still needed from all stakeholders, along with the hard work of thousands of health workers and volunteers to bring vaccines to every last child.

Acknowledgments

None.

Conflicts of interest

None.

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