POLIOMYELITIS (POLIOVIRUS)

ABSTRACT

The primary focus of Polio social science research has been on the developing world. This includes nations that are still endemic or at risk of epidemics. In 2022, poliovirus strains closely resembling each other were found in the sewage systems of various London boroughs and counties in New York State. In both the US and the UK, healthcare professionals and the public believed that these instances represented the first occurrence of polio in a generation. Vaccine hesitancy poses a considerable obstacle to vaccination initiatives and is shaped by societal customs, misinformation, and mistrust toward immunization personnel. Although 45 million children are on track to receive vaccinations, tackling these complex challenges requires a comprehensive approach that transcends traditional immunization efforts. Polio has posed a major public health challenge since the early 1900s, leading to widespread vaccination efforts worldwide. The use of the oral poliovirus vaccine (OPV) and the inactivated poliovirus vaccine (IPV) has greatly decreased the incidence of polio globally. Present efforts are concentrated on achieving complete eradication. However, despite these actions, polio remains endemic in specific regions, highlighting the need for continuous monitoring and vaccination to prevent a possible resurgence.

Keywords: “Poliomyelitis”, “Wild Poliovirus”, “Polio Eradication Strategies”

Authors

Iqra Hasan
SBT IFTM University
Moradabad.

Dr. Swapna Kumar Srivastava
SBT IFTM University,
Moradabad.

Dr. Mohd Usman Mohd Siddique
SVKM's Institute of Pharmacy
Dhule, Maharashtra.

Dr. Prevesh Kumar
Pharmacy Academy
IFTM University
Moradabad.

I. INTRODUCTION

The poliovirus is the infectious agent that causes the disease. About 75% of cases are asymptomatic, mild symptoms like fever, and sore throat are common. In just a few percent of situations more serious symptoms including headache, stiff neck, and paraesthesia appear. These symptoms often disappear after two weeks or so. After recuperation, post-polio condition after years can manifest as a steady deterioration of muscular weakness like that seen during the disease. PV may target the nervous system, and children under the age of five, most commonly affected by its debilitating effects. Since 1988, wild poliovirus infections it has collapsed greater than 99 percent in 2021, they were only 6 cases documented. Compare more than 125 endemic countries with an estimated 350,000 cases. In 1999, wild poliovirus type 2 was eradicated whereas the eradication detection of wild poliovirus type 3 in 2020.

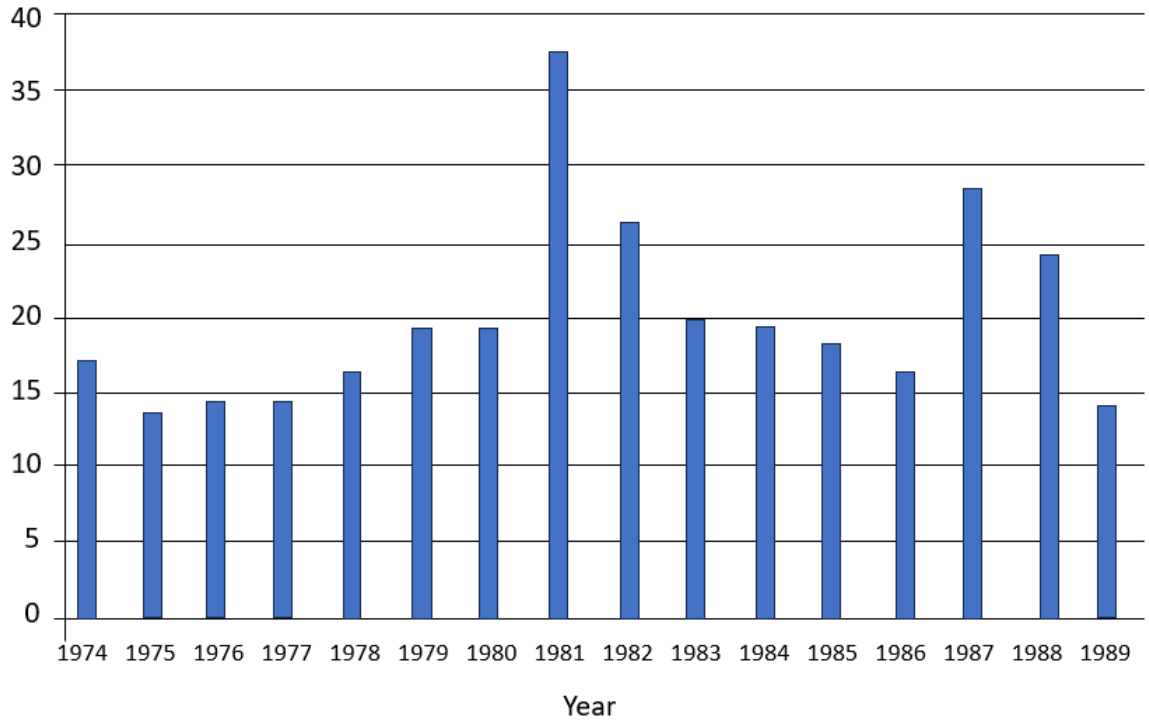

Figure 28: Total Number of Poliovirus Cases between 1974 to 1989

1. **Historical Significance and Impact on Public Health:** The most natural reservoir for PV is human, and its host range is restricted. The primary means of transmission include contaminated food and drink, as well as the fecal-oral route. In order to infect host cell, all three PV serotypes attach to a similar cellular receptor known as CD155 (also referred to as the PV receptor or PVR for short). PV must bind to CD155 to cause a shift in the

viral capsid's structure thereby releasing the process known as decapsidation involves releasing viral RNA into the infected cells' cytoplasm. The virus initially multiples in the small intestine and throat upon infection, especially in the lymphoid tissues, such as Peyer's patches and tonsils. After then, PV enters the bloodstream and moves the cervical and mesenteric regional lymph nodes. Children who are not vaccinated are more vulnerable to polio, which is more common among pregnant mothers. Polio has no known treatment, although immunization can help avoid contracting. Being symptomless, 90% infected individuals remain untreated and end up the spreading the virus. Global Polio Eradication, World Health Organization (WHO) Programme is the World’s largest public health campaign. Only wild poliovirus type 1 is still present, whereas wild poliovirus type 2 was declared extinct in 2015 and 2019, respectively.

2. **Description of Serotypes of Polio:** The World Health Assembly approved a resolution in 1988 indicating that polio must be eliminated by the year 2000. There has been significant advancement in this area. Two of the three wild poliovirus (WPV) serotypes, PVS type 2 (PVS2) and PVS type 3 (PVS3), have been eliminated or eliminated globally since 2012. The only countries where PVS type 1 (PVS1) is still prevalent and in use are Afghanistan and Pakistan. The eradication objective can be accomplished.

   In Pakistan and Afghanistan, wild-type PV-1 remains widespread and localized as of March 2020. Wild-type PV-2 was last identified in 1999 and was eliminated from local transmission in September 2015, and wild-type PV-3 was discovered in October 2019 after being last detected in 2012.In 2012, the final WPV3 case was discovered in northern Nigeria. Since then, confirming that this strain has actually disappeared has depended heavily on the effectiveness and scope of the eradication program's worldwide surveillance system. As a consequence of the ongoing OPV, or oral polio vaccination, uses serotype 2, report that 683 instances of polio were brought on by the dissemination of poliovirus type 2 produced from vaccines (cVDPV2) from 2000 to 2014. As per the findings of a study from 2017, a total of 155 nations and territories utilized OPV in the year 2015. The strategic consultancy firm Sage has an ample supply of inactivated polio vaccines (VPIs) to cater to the global population during the transition period, despite the limited availability of high-value IPV vaccines. Vaccination against oral polio involves strains of the three poliovirus serotypes that are live but attenuated. Infecting monkey kidney epithelial cells with virus strains causes modifications to the viral IRES, which lessens or stops the virus's ability to infect muscle tissue.

3. **Mechanism of Infection:** Poliovirus, initially recognized in 1909 as a public health hazard and then as a model system, has been the subject of much research since then (Leveque &Semler, 2015; Racaniello, 2006).The Picornaviridae family of viruses includes the single-stranded, non-enveloped RNApoliovirus. Intestinal viruses spread through the fecal-oral pathway. Like other RNA viruses, the poliovirus makes about one error before each replication cycle. The poliovirus recombination frequency in cultured cells was 1.3 × 10 is base & –3 is power at a high multiplicity of infection (MOI), according to Kirkegaard and Baltimore (1986). In other words, genetic recombination is responsible for around one out of every 1300 genomes.

   During a normal human infection, there is evidence that the poliovirus can recombine with other enteroviruses; this recombination is also observed in vivo. Furthermore, research by Holmblat et al. indicated that poliovirus genomes exhibiting defects may undergo recombination, potentially restoring their fitness within the host. This is supported by the fact that poliovirus replication complexes, which are connected to cellular membranes, are essential for viral replication. Like all other (+) RNA viruses of eukaryotes, these complexes play a crucial role in the virus's life cycle. Additionally, poliovirus and other related picornaviruses have been shown to be vulnerable to brefeldin A (BFA), a fungal metabolite that interferes with the function of major guanine nucleotide exchange factors (GEFs) for small GTPases, including Arf, GBF1, BIG1, and BIG2. These GEFs facilitate the exchange of GDP for GTP, promoting the activation of small GTPases like Arf.

4. **Poliomyelitis Clinical Stages:** After five to ten days of incubation, around 25% of infected individuals have a prodromal sickness that includes irritability, restlessness, lethargy, and discomfort in the extremities. Of those patients, 30% also experience respiratory symptoms. Less than 5% of patients with the infection experience an acute phase following the resolution of the prodromal symptoms. This phase can be defined by a high temperature that appears quickly, accompanied by limb weakness, irritability, and, sometimes, meningeal irritation symptoms. Less than 1% of individuals with an infection (about 5% of patients who go through the acute phase) develop the paralytic stage one to four days after the acute stage. During this time, anterior horn cell/grey matter neuronal damage causes non progressive flaccid paralysis to suddenly develop in one to four limbs. The paralysis then goes away in many muscle groups during the reparative stage, which might develop gradually over several years.

5. **Epidemiology:** Through the oral or fecal-oral routes, wild poliovirus (WPV) is transmitted from one individual to another. Most likely, oral-oral transfer is the main way that in industrialized nations with good standards of cleanliness, whereas fecal-oral dissemination is more prevalent in impoverished nations. Three to six days pass between infection and the start of the first symptoms (a small sickness), and seven to twenty-one days pass between infection and the beginning of paralytic disease. The duration of poliovirus excretion is around two weeks in saliva and three to six weeks in feces.

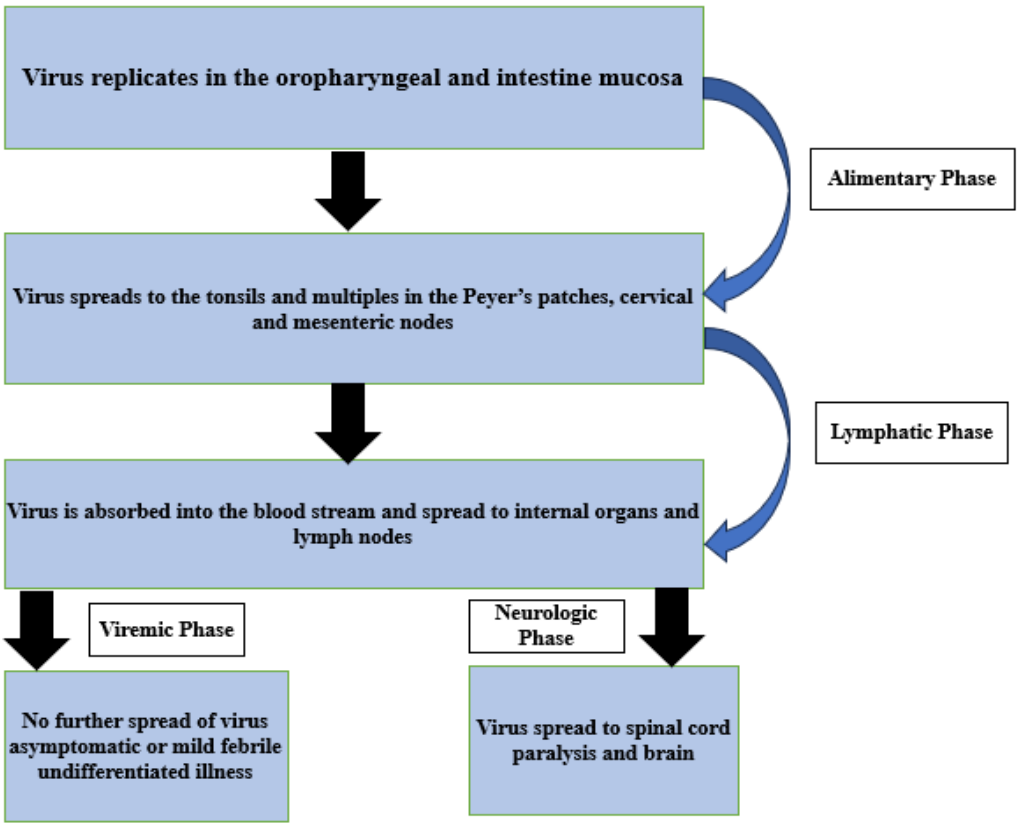

Figure 29: Epidemiological Situation

6. **Laboratory Procedures for Isolation and Identification:** Since 1988, laboratory diagnosis has been essential to the Global Initiative to End Polio since it can identify detect the poliovirus (PV) has been identified thus far by isolating the virus. Using stool samples from cases of acute flaccid paralysis (AFP), including polio paralysis, and other paralysis using cell culture techniques; these stool samples were obtained by individuals with AFP. The cell culture-based approach has the following advantages:

   - The low requirements of the equipment.

- A high level of sensitivity (detection limit of one infectious unit with 50–1,000 virions) and above all.
- Biological amplification of high titles PV (approximately 106 50% infectious dose of cell culture [CCID50] or 108 to 109 copies of the viral genome per µl of cell cytoplasm) for the examination of the VP1 coding area of the capsid protein's following Nucleotide sequence, which is required for the PV strains' ultimate identification and molecular epidemiological investigation.

With molecular epidemiological techniques, sequencing is crucial to detect viral tanks, the categorization of PV isolates in vaccination strains, wild strains and the circulation of PV strains derived from vaccinations (VDPV) and evaluating the needs of regimes of additional vaccination. Reverse transcription (RT)-PCR is a viable and reasonably priced method for the direct detection and diagnosis of PV. However, a significant obstacle has been the pan PV PCR's sensitivity [for example 25,000 copies for the detection of PV1 (Sabin)]. The inherent characteristics of degenerate primers and probes, which employ inosine and modified nucleotides to identify distinct nucleotide sequences conserved among the three forms of PV in the VP1 coding region, may be the reason for this low sensitivity.

Polio laboratories in India use the highly poliovirus-specific L20B cell line and the RD cell line, which comes from rhabdomyosarcoma in humans. The cytopathic impact of the virus on the cell lines determines its growth. This normally happens seven days after the inoculation. Inoculation is performed in the cell line L20B to verify poliovirus if the RD cell line is the only one exhibiting cytopathic alteration. Following that, using specific antisera for serotyping, the isolate is subjected to neutralization testing. Additionally, tests are performed to identify the isolate as either a wild strain or a strain generated from a vaccination. These evaluations are referred to as intertypic differentiation tests. These are based on the idea of the enzyme-linked immunosorbent test or hybridization techniques.

7. **Treatment:** Polio has no approved remedy, but the purpose of treatment is to control its symptoms while the virus is still active. This may include helping a patient breathe. Using analgesics to lessen headaches, muscular aches, and spasms, and antibiotics to treat urinary tract infections. Additionally, to optimize the rehabilitation of muscular strength and function, orthopaedic surgery or physical therapy may be required. It is important to keep in mind that patients are most contagious seven to ten days before and following the development of symptoms while analysing the spread of illness. The goal of

treatment is to teach you how to manage your symptoms and continue to be active despite your muscular weakness. A balanced combination of rest and exercise, heat and ice, pain medication, and a nutritious diet can help you manage your symptoms.

There aren't any particular drugs to treat polio. Physical treatment will be administered to you if you have paralytic polio. If you have weak or paralyzed breathing muscles, you will require mechanical ventilation, which is a breathing apparatus. It may be possible to alleviate your discomfort by:

- Consuming liquids (water, juice, and broth, for example).
- To relieve muscular pains, apply heat packs.
- Using ibuprofen (Advil®, Motrin®) or other painkillers.
- Following your doctor's recommendations for physical therapy and exercise.

8. **Polio Vaccine:** All around the world, poliomyelitis, also referred to as polio, is prevented with polio vaccinations. Jonas Salk created the first, which was put to the test for the first time in 1952. Salk first revealed it to the public on April 12, 1955. It involves injecting a dosage of inactivated (dead) poliovirus. Albert Sabin used attenuated poliovirus to create an oral vaccine. Sabin's vaccine was approved in 1962 after human testing started in 1957. Since polioviruses do not have a long-term immune-competent carrier state people, they do not have a nonprime reservoir in nature, therefore it is unlikely that they will survive in the environment for a long time. Therefore, the most important step in the global elimination of polio is vaccination, it prevents the virus from infecting other people. Most nations have eradicated polio thanks to the two vaccinations, which have also decreased the global frequency from 1,652 occurrences in 2007 to an estimated 350,000 cases in 1988.

   In past decades, when polio outbreaks were widespread, there was a complete lack of awareness about how to treat this severe disease. Chronic instances with abnormalities presented rehabilitation challenges, whereas acute cases needed pain management right away. Several approaches to handling these problems were popular at the time. There was a great deal of experimenting as well. Australian nurse Sister Elizabeth Kenny's valiant efforts are among the first accounts of polio care techniques. She prohibited the practice of immobilizing afflicted limbs for extended periods of time and utilized hot packs to treat muscular spasms in the early stages of the condition, numerous patients benefitted from it.

8.1 Types of Vaccine

8.1.1 Inactivated Polio Vaccine (IPV)

Salk created the first inactivated polio vaccine (IPV) by using formalin to render a virus that was cultured on monkey kidney cells inactive. 1.6 million Children from Finland, Canada, and the United States in 1954 participated in a placebo-controlled study to assess the inactivated vaccine. Salk's vaccine was embraced nationwide in April 1955. Between 1954 and 1996, the number of cases of paralytic poliomyelitis in the United States dropped from 13.9 to 0.8 per 100,000. The shortcomings of the Salk vaccination at the time included the fact that, within a few years of vaccination, the titters of the circulating antibody decreased, that wild PV continued to circulate and could cause outbreaks, and that a significant number, it required the death of around 1500 monkeys for every million inactivated doses. There were three distinct viral strains included in the vaccination are MEF-I (type 2), Saukett (type 3), and Mahoney (type l). Ten fatalities and 260 cases of PV type 1 poliomyelitis resulted from Cutter Laboratories in Berkeley's failure to inactivate the vaccine virus shortly after the Salk immunization was licensed.

It was suggested that the virus could have clumped together, making it immune to formaldehyde inactivation. To eliminate aggregates that could have formed during treatment, a second filtering step was added to the production process, and safety testing was improved. The controversy surrounding the use of the very virulent Mahoney strain to create vaccines has always existed, but it intensified significantly following the Cutter event.

8.1.2 Oral Polio Vaccine (OPV)

OPV is the recommended vaccination in the majority of the globe due to its low cost, 3 conveniences of use, and ability to rapidly stop virus transmission by more closely resembling a naturally occurring disease since it is administered orally. Along with receiving the same vaccination three times, separated by at least four weeks, the Expanded Schedule for Vaccination (EPI) of the World Health Organization (WHO) presently advises trivalent OPV as part of the normal vaccination schedule at birth. Nonetheless, the great OPV's majority (either as a monovalent, bivalent, or trivalent vaccine) is given during supplemental vaccination programs in an effort to quickly reach a large percentage of the targeted children. However, the most majority of OPV vaccines, whether they are trivalent, bivalent, or monovalent, are given as part of supplemental vaccination programs in an

effort to quickly cover a large percentage of the targeted children. This method is necessary to accomplish eradication as it expedites the logistics (e.g., cold chain, vaccinators) and increases population immunity. Another form of attenuating mutation that might modify how the virus interacts with its receptor is "non-consensus" capsid amino acid changes on the virion surface. N-Ag substitutions and other attenuating alterations are subject to negative selection when the poliovirus vaccination strain multiplies in the intestines.

Since OPV virus is eliminated in feces and nasopharyngeal secretions, OPV may potentially indirectly vaccinate the close contacts of vaccination recipients. An OPV campaign in Yaoundé, Cameroon, reduced paralytic poliomyelitis cases by 85%, despite the fact that only 35% of children aged 12 to 13 months received three doses of OPV.

A Comparative Analysis of Oral and Inactivated Polio Vaccination:

OPV (Oral Polio Vaccine)	**IPV (Inactivated Polio Vaccine)**
• Live Attenuated (weekend) virus	Killed Virus
• Administered by drops	Administered by Injection
	
• Inexpensive	More expensive then OPV
• Easy to administer	Requires trained health worker
• Provides mucosal/gut immunity	Provides immunity through blood

9. **Global Polio Eradication Efforts and Progress:** In 1988, the World Health Organization (WHO) launched the Global Polio Eradication Initiative (GPEI) with the aim of eradicating polio worldwide by the year 2000. However, despite significant progress, the goal has not yet been fully achieved, and polio remains relatively prevalent in regions such as South Asia and sub-Saharan Africa. There are three stages to the polio eradication campaign:

Phase I (1988-2000): In 1988, the Global Polio Eradication Initiative (GPEI) was started by the World Health Organization (WHO). The intended

goal of eliminating polio by the year 2000 has long since passed, and the disease is still rather prevalent in South Asia and sub-Saharan Africa.

Phase II (2001-2007): New hope for the successful eradication was sparked by the low global incidence of 493 cases in 2001. But this hope was short-lived. Due to continuous endemic transmission in Nigeria and India, the incidence swiftly increased to 1000–2000 cases annually. Surprisingly, these two countries had different causes of the continuous transmission. While endemic polio was eliminated in other parts of India, endemic polio transmission continued in the northern belt districts despite high vaccination rates. In Nigeria, opposition to OPV distribution led to low coverage rates of the oral polio vaccine (OPV). From these two epicentres, exports to several countries were frequent.

Phase III (2008 Onwards): In 2010, the prevalence of polio had significantly decreased in Nigeria and India because of a significant increase in the global effort, new WHO leadership, and targeted donor agency research assistance that resulted in the deployment of monovalent and bivalent OPV vaccinations. Both positive and negative news have been reported throughout the first half of 2011. The good news is that India has only recorded one case. However, certain nations in sub-Saharan Africa still record persistent outbreaks. The goal of current international initiatives is to eradicate all wild poliovirus transmission globally by 2012.

Given our own experiences working for the GPEI and smallpox eradication for many years, both in the field and in central offices, we would want to share our occasionally critical but supportive opinions on how to complete the last stage of polio eradication. We will start by talking about the lessons that have been discovered throughout each stage of the eradication of polio. After that, we would want to share our thoughts on how to accomplish the "safe landing" of polio eradication worldwide.

10. **Future Perspective:** Several important strategies and factors will be considered seriously in determining the future direction for poliovirus eradication.
    - **Completing the Eradication Process:** The aim is to stop wild poliovirus from spreading in the remaining endemic nations. Vaccination and tactical strategies are essential to reaching this objective. If these aren't put into practice, virus propagation may continue.

- **Endgame Strategy for Polio:** A comprehensive polio eradication strategy for 2019–2023 has been meticulously crafted by the Global Polio Eradication Initiative (GPEI). The primary objectives are to contain, eradicate, coordinate, and ultimately confirm a world free of polio.
- **Development of Novel Vaccines:** Novel advances in poliovirus vaccines are essential. To improve worldwide immunization campaigns, new, safe, and effective inactivated poliovirus vaccines (IPV) are being developed.
- **Taking Care of Low-Level Transmission:** To stop the virus from resurfacing, more care is required in nations where low-level transmission continues particularly in densely populated areas.

Taking Care of Low-Level Transmission- To stop the virus from resurfacing, more care is required in nations where low-level transmission continues particularly in densely populated areas.

II. CONCLUSION

It might be the poliovirus's last fight. However, success is not guaranteed. Absolute ownership—from parents seeking the vaccination to local authorities understanding the task of eradicating polio from their regions—is the one magic ingredient that is still lacking in the remaining endemic countries. If complete ownership is not achieved, national pride is at risk. The new strategic plan of the GPEI must differ greatly from its predecessors. It needs to give human factors just as much attention as technological ones. It must thoroughly present the arguments for why polio can and should be eliminated, as well as how this will be accomplished. It must attract everyone on the planet who can contribute to making this truly the last struggle against polio.

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