

Epidemiology and Control of Poliomyelitis

*Dr. Akinola A. Fatiregun MBBS, MSc (Epid & Med Stat), FWACP
Department of Epidemiology, Medical Statistics and Environmental Health,
Faculty of Public Health, College of Medicine,
University of Ibadan, Ibadan, Nigeria.*

SUMMARY

The World Health Assembly (WHA) declared that the World Health Organization (WHO) was committed to the global eradication of poliomyelitis. As with smallpox, eradication involves the additional criterion of the elimination of indigenous transmission of wild virus. This article reviews the epidemiology of poliomyelitis, strategies for polio eradication and the progress made so far. Threats to eradication objectives are identified and changes in polio eradication initiative deadline are outlined.

INTRODUCTION

Drawing from the successful smallpox initiative, the World Health Assembly (WHA) resolved to eradicate polio from the world by the year 2000[1]. As was the case with smallpox virus, poliovirus causes acute non-persistent infections, humans are the only reservoir, virus survival in the environment is limited, and immunization with vaccine interrupts virus transmission. Collectively, these factors make polio virus a candidate for eradication [2].

The smallpox eradication effort led by the World Health Organization (WHO) in the 1960s and 1970s offers a clear example of the financial and humanitarian benefits that accrue to the world community after total eradication of a disease. Since the last case of smallpox was detected in 1977, billions of dollars have been saved in vaccine procurement. More importantly, thousands of deaths and millions of cases of a disabling disease are averted each year. The global eradication of polio is expected to offer similar benefits to humankind. Worldwide, an estimated \$1.7 billion is expected to be saved each year[3].

All Correspondence to Dr Akinola A. Fatiregun

Department of Epidemiology, Medical Statistics and Environmental Health, Faculty of Public Health, College of Medicine, University of Ibadan, Ibadan, Nigeria.
E-Mail: akinfati@yahoo.com

The goal of global eradication of wild polio virus was defined as: no cases of clinical poliomyelitis associated with wild poliovirus, and no wild poliovirus found worldwide despite intensive efforts to do so. The primary strategies for achieving this goal are two folds. One is the administration of polio vaccine in the manner most effective to interrupt transmission of wild poliovirus. This includes attaining high routine immunization coverage with at least three doses of oral polio vaccine, conducting national immunization days (NIDs) and "mopping-up" immunization when polio is reduced to focal transmission. The other strategy is the implementation of action-oriented surveillance for all possible cases of poliomyelitis. This includes case investigation and isolation of virus from stool specimens[4].

Polio is a disease that does not respect national borders or continental boundaries, and in that sense is truly a problem of global concern requiring large-scale international cooperation. The progress to date has been marked by cooperation and coordination among countries and regions of the world. Also the efforts of polio endemic countries have been encouraged and supported by an effective coalition of partners including WHO, Rotary International, and United Nation Children Fund (UNICEF) and the governments of Australia, Canada, Denmark, Finland, Germany, Japan, Norway, Sweden, the United Kingdom, the United States etc. The participation of Rotary International represents the largest contribution ever by a private sector organization to a public health initiative[2].

As at the time the goal to global eradication of poliomyelitis was established in 1998, wild polio virus (WPV) was endemic in more than 125 countries on five continents paralyzing more than 350,000 children per annum. Only 1,170 confirmed cases of polio were reported in 2004 representing a greater than 99% reduction in poliovirus. Today, only 6 countries in the world remain endemic and these include Nigeria, India, Pakistan, Niger, Afghanistan

and Egypt [5]. Experience in the Americas, where polio has been eliminated since August 1991, demonstrates that the recommended strategies are effective and the global eradication of polio is feasible [2].

Epidemiology of Poliomyelitis

The words *polio* (grey) and *myelon* (marrow) are derived from the Greek. It is the effect of the poliomyelitis virus on the spinal cord that leads to the classic manifestation; paralysis[6]. The Polio virus is a member of the enterovirus subgroup family picornaviridae. They are transient inhabitants of the gastro-intestinal tract (GIT) and stable at acid pH like other enteroviruses. They are small, ether-sensitive with RNA genome. There are 3 serotypes, P1 P2, and P3. P1 most typically causes outbreaks, and is the most likely serotype to cause paralysis. P2 is the easiest to eradicate followed by P3. They are all rapidly inactivated by heat, formaldehyde, chlorine, and UV light [8].

Poliovirus infects only human beings and there is no animal reservoir. The virus does not survive long in the environment outside the human body and there is no long-term carrier state. Person-to-person spread via faeco-oral route is the most important route of transmission. Oral-oral route may also account for some cases. Two peaks of transmission, Feb to May (low transmission period) and August to November (high transmission period) in Africa are recognized, while transmission peaks in winter in the temperate countries. Cases are most infectious from 7 to 10 days before and after the onset of symptoms[6, 7].

The portal of entry is the mouth. Primary replication occurs in the pharynx and GIT. The virus invades local lymphoid tissue, enters the blood stream and may infect cells of the CNS. Replication in motor neurons of the anterior horn cells and brain stem results in cell destruction and causes the typical manifestation of poliomyelitis. The virus is usually present in the throat and in the stools before the onset of illness. One week after onset, there is little virus in the throat, but the virus continues to be excreted in the stools for several weeks[6].

The incubation period is commonly 6 to 20 days with a range from 3 to 35 days[8]. Up to 95% of all polio infections are sub clinical without symptoms. An estimated ratio of asymptomatic to paralytic illness is usually 200:1. Notwithstanding, infected asymptomatic persons shed virus in the stool, and are able to transmit the virus to others. About 4 to 8% of infections are non-septic without clinical or laboratory evidence of central nervous system (CNS) invasion. This type of infection is described as abortive poliomyelitis. The symptoms observed range from upper respiratory tract infection (sore throat, fever), gastro intestinal disturbances (nausea, vomiting, abdominal pain, constipation and rarely diarrhoea), to influenza - like illness. In 1 to 2% of infections, non-paralytic aseptic meningitis occurs usually following non-septic illness with stiffness of the neck, back and legs. Typically, these symptoms last 2 to 10 days followed by complete recovery. Less than 2% of all polio infections result in flaccid paralysis. Paralytic symptoms generally begin 1 to 10 days after prodromal symptoms and progress for 2 to 3 days. The prodrome may be biphasic, especially in children with initial minor symptoms separated by a 1 to 7 day period from more major symptoms. Additional prodromal signs and symptoms can include loss of superficial reflexes, initially increased deep tendon reflexes and severe muscle aches and spasms in the limbs or back. The illness progresses to flaccid paralysis with diminished deep tendon reflexes, reaches a plateau without change for days to weeks then strength begins to return. The paralysis is asymmetrical with no sensory losses or changes in cognition. Many affected persons recover completely and in most cases, muscle function returns to some degree. Patients with weakness or paralysis 12 months after onset will usually be left with permanent residuals[6, 7, 8]

There are 3 clinical types of paralytic polio. Spinal polio is most common and accounts for 79.5% of paralytic cases characterized by asymmetric paralysis that most often involves the legs. Bulbar polio accounts for 2% of cases and leads to weakness of muscles innervated by cranial nerves. Bulbosspinal polio accounts for 19% of cases and is a combination of bulbar and spinal paralysis. The

case fatality ratio (CFR) for paralytic polio is 2 to 5% in children and up to 30% in adults depending on age. It increases to between 25% and 75% with bulbar involvement [9].

Protective immunity against poliovirus infection develops following immunization or natural infection. Immunity to one poliovirus type does not protect against infection with other poliovirus types. Immunity following natural infection or administration of live oral polio vaccine (OPV) is believed to be lifelong. The duration of protective antibodies after administration of inactivated polio vaccine (IP) is unknown. Infants born to mothers with high antibody levels against poliovirus are protected for the first several weeks of life [10].

The differential diagnosis of acute flaccid paralysis include paralytic poliomyelitis, Guillain-Barre syndrome and transverse myelitis; less common aetiologies are injection neuritis, encephalitis, meningitis and tumors [4]. Distinguishing characteristics of paralytic polio are asymmetric flaccid paralysis, fever at onset, rapid progression of paralysis, residual paralysis after 60 days, and preservation of sensory nerve function.

Definitive diagnosis of poliomyelitis is by viral isolation. Polio virus may be recovered from stool or pharynx. Isolation of virus from the cerebrospinal fluid (CSF) is diagnostic but rarely accomplished. Oligonucleotide mapping or genomic sequencing is required to differentiate wild like or vaccine-like virus [11]. Neutralizing antibodies appear early in the serum and may be at high levels. CSF shows an increased number of WBC (10 to 200 cells / mm³) and mildly elevated protein (40 to 50 mg / 100 mls) [6].

Mass immunization with polio vaccine is the sole effective means of preventing poliomyelitis. Killed and live - attenuated vaccines are available and are both safe and effective when used correctly. High standards of personal and environmental hygiene especially sanitary disposal of sewage and provision of adequate and safe water supply are other proven primary preventive measures. These, in combination with community health education constitute the primary preventive package for control of poliomyelitis. There is no specific treatment

for polio. Good nursing care, from the beginning of illness can minimize or prevent crippling. Physiotherapy initiated in the affected limb on time is of vital importance. It helps the weakened muscles to regain strength, as is likely the child may have to be put on metal calipers [6, 7, 8].

Strategies For Polio Eradication

Polio transmission has been interrupted in the regions of the Americas, the Western Pacific, and Europe to date. The eradication of Polio in countries of these regions has demonstrated the effectiveness of the polio eradication strategies. Attaining and sustaining high routine coverage of more than 80% with at least 4 doses of oral polio vaccine given at birth, 6, 10 and 14 weeks thereafter respectively is one strategy known to effectively interrupt transmission. However, the infrastructure as well as the financial commitment to achieving this, are lacking in most polio endemic countries. Hence the need for supplementary immunization activities, conceived to improve coverage on a short term, and serve as basis to strengthened routine immunization. Conduct of national immunization days and sub-national or mop-up immunizations are such supplementary immunization activities [4].

During national immunization days (NIDs), doses of OPV are given to all children in a defined age group, usually 0-59 months of age, in as short a period of time as possible (preferably 1-2 days), regardless of their immunization status. The doses of OPV administered during NIDs are considered extra doses, which supplement and do not replace the doses received during routine immunization services. The planning and execution of NIDs is a major public health event receiving much publicity and involving many participants in the public and private sectors. The logistic, coordination, and social mobilization of NIDs are carefully planned well in advance for excellent implementation. By giving oral polio vaccine at the same time to all children over a short period of time in a large geographic area, transmission of poliovirus is interrupted. To be effective, NIDs must achieve high coverage with OPV. Therefore, special efforts are necessary to

reach children who are often missed by the routine immunization programme. For those already immunized, NIDs boost both serum and intestinal immunity against poliovirus.

Mop-up immunization is conducted when polio has been reduced from an endemic disease (i.e. occurring throughout the country) to a disease that occurs only in focal areas. It is usually implemented during the low season of polio transmission. Exception occurs in countries where polio virus is thought to have been eliminated or almost eliminated; mop-up immunization might be conducted immediately after a case is confirmed as polio, regardless of the season [4].

Acute flaccid paralysis (AFP) surveillance is another important strategy in polio eradication. Its purpose is to detect reliably areas where poliovirus transmission is occurring or likely to occur; and to allow supplementary immunization to be focused where it is needed. As the number of polio cases approaches zero, the ability to detect and respond rapidly to every case of AFP becomes critical. To ensure that every case of polio is detected intensive surveillance for AFP has to be conducted.

AFP surveillance allows programme managers to monitor progress and to determine whether strategies are implemented effectively. Certifying a country as polio-free requires that there are no reports of new cases of poliomyelitis caused by wild poliovirus. It also requires evidence that a country can detect a case of paralytic polio should it occur. As an indicator of a country's ability to detect polio, at least 1 case of AFP per 100,000 children <15 years of age should be detected, even in the absence of polio. The AFP rate in children < 15 years of age is an indicator of the sensitivity of the surveillance system [12].

Isolation and identification of poliovirus from the faeces is the best current method to confirm the diagnosis of poliomyelitis. WHO, in collaboration with several other institutions, has developed a global network of laboratories to provide this service. Molecular techniques are available to characterize fully the poliovirus. Maintaining a reference bank of the molecular structure of known viruses allows the geographic origin of new isolates to be traced. When countries are polio-free or almost polio-free, it is

necessary to determine whether the virus was imported or indigenous. The laboratory will also determine whether isolated viruses are wild or vaccine-like. The global laboratory network is a 3-tiered system. Each tier provides different services, all of which are essential and must be coordinated. The network also coordinates the flow of specimens, reagents and information between different levels of laboratories and between laboratories and programmes. The laboratory network will play a key role in certification of polio eradication by verifying the absence of wild poliovirus circulation. In addition to AFP surveillance, this may include stool surveys of healthy children in high-risk area and environmental surveillance. The laboratory network can perform potency tests on polio vaccine if circumstances indicate possible failure. In selected situations, a laboratory might participate in epidemiologic sero-surveys if knowledge of the antibody status of the population or a given cohort is important [13].

AFP surveillance consists of: detecting, reporting and investigating suspected cases, collecting data from reporting sites, analyzing data and using them for action, reporting findings and lastly providing feedback (information) to all levels and interested parties. To have a sensitive and responsive surveillance system of suspected polio, immediate notification of AFP in children aged <15 years of age is required. When no case of AFP is detected, reporting units should still send a monthly/weekly report indicating zero cases. This is called "zero reporting". To improve completeness, timeliness and sensitivity of AFP surveillance for instance in Nigeria, WHO has designated persons in all the 36 states and Abuja who make weekly visits to sites likely to have cases of acute polio, such as major hospitals and rehabilitation centres. Visits are made particularly to paediatric and neurology wards to inquire about cases of AFP, including Guillain-Barre syndrome. A search of all inpatient and outpatient medical records is also conducted for review of preliminary and final diagnoses. For the purpose of surveillance, any sudden weakness in any of the limbs in a child less than 15 years, occurring within two months of detection or report is considered an AFP case [4].

Progress in Global Eradication of Poliomyelitis

Five years after the year 2000, the date initially proposed for the global eradication of polio has been elusive though considerable progress has been made. A major tactical revision in the initiative was introduced in 2003, leading to a revised time frame for certification of eradication now in 2008. In the new agenda, poliovirus transmission is expected to be stopped by the middle of 2005, achieve certification standard surveillance in all countries by the end of 2005 and finish supplementary immunization by the end of 2006 [14].

The eradication of Poliomyelitis as with smallpox, involves the additional criterion of the elimination of indigenous transmission of wild virus. However, poliomyelitis is inherently more difficult to eradicate than smallpox. Among the epidemiologic characteristics in which the two diseases differ are the asymptomatic illness that is characteristic of most polio infections and the ability of the poliovirus to spread by enteric transmission, both of which make the identification and containment of cases more difficult. In contrast, smallpox was clinically obvious and eradication was quite easy to confirm. Differences between the vaccines are also important. Smallpox vaccine is heat stable, one dose is required for protection lasting several years, and vaccination leaves a readily visible scar. Trivalent OPV loses substantial potency after one day at 37°C and multiple doses are required for full protection. Another difference is that properly administered smallpox vaccine has been a highly effective immunogen, whereas sero-conversion rates after one to four doses of OPV have been suboptimal in developing countries[2]. Confirming that poliovirus has stopped being transmitted will therefore require far more sophisticated test and facilities.

In spite of these and other differences, the eradication of smallpox provides a model for success. Substantial progress had been made in global polio eradication with NIDs and AFP surveillance, but Nigeria currently poses the highest risk to the achievement of the global goal. With a case load of 792 cases in 2004 alone, Nigeria had the highest number of polio cases anywhere in the world, and this accounted for 63% of the global wild polio case

count and 84% of the cases in Africa. The number is more than 2 times compared to 2003 case total case count [5].

Poliovirus from the northern part of the country is re-infecting previously polio free areas within and outside Nigeria. Exportation of virus from Nigeria had been reported in Republic of Benin, Burkina Faso, Cameroon, Chad, Ghana, Niger, Togo, and more recently Saudi Arabia, Ethiopia and Yemen.

Many states in southern Nigeria were polio free from mid - 2001 to mid - 2003, demonstrating that transmission can be stopped in the country with high quality immunization campaigns. However, since the OPV safety issue emerged in 2003 and with subsequent stoppage of NIDs for some part of 2003 coupled with poor routine immunization coverage, viruses spread to all southern states with the exception of Ekiti, Edo, Ebonyi, Abia, Rivers, and Akwa-Ibom states. To make matters worse, indigenous virus was found in Oyo state.

CONCLUSION

The greatest threat to a polio free world include a failure to reach all children with immunization in the endemic nations especially in Nigeria, India and Pakistan combined with ongoing insecurity in some countries with re-established transmission particularly Cote-d'Ivoire and Sudan. Also gaps in sub-national surveillance of the disease particularly in West, Central and Horn of Africa coupled with low immunization rates in these countries are other challenges the polio eradication initiative faces. WHO estimates that US\$75 million and US\$200 million will be needed for the later half of 2005 and all of 2006 for PEI activities respectively. These funds are still being sourced.

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