Poliomyelitis era in Trinidad from 1940 to 1972 and beyond: Implications for effective global health governance for its eradication

Kameel Mungrue¹, Vijay Kumar Chattu¹

¹Department of Paraclinical Sciences, Faculty of Medical Sciences, Eric Williams Medical Sciences Complex, Mount Hope, The University of the West Indies, St. Augustine, Trinidad and Tobago

ABSTRACT

Background: Acute poliomyelitis (APM/polio) is a viral infection caused by the polio virus that continues to have a fascinating social and economic impact on countries throughout the world. Humans acquire the virus by close personal contact with transmission occurring through the fecal–oral route. The majority of poliovirus infections results in no illness or produces only self-limited symptoms, however in approximately 5% of infected patients flaccid paralysis of the limbs can occur and 1% can die. Although APM is no longer a feared disease mainly due to the development of effective vaccines, its eradication remains elusive. Methods: The aim of this study is to review the historical impact of APM in Trinidad. A retrospective analysis of all cases occurring from 1939 to 1972 was undertaken. Data for the study were derived from two sources the Annual Statistical Reports of the Ministry of Health 1972–2000 and the epidemiological publications of the League of Nations Health Organization and the World Health Organization. Results: There were four outbreaks of APM in Trinidad 1941, 1942, 1954, and 1972. After the final outbreak in 1972, APM was eradicated not only from Trinidad but also all the countries of the Americas mainly through the effective use of the oral polio vaccine. Conclusion: Polio has brought together international agencies, governments, and the people to build an effective public health system around a common vision for health and wellbeing. The polio eradication and endgame strategic plan represents a major milestone in polio eradication developed by global polio eradication initiative. The initiative would still benefit from adopting some of the best practices in governance from other organizations in the global health sector.

Keywords: Acute poliomyelitis, flaccid paralysis, global health diplomacy, global health governance, global polio eradication initiative, oral polio vaccine

Introduction

Viruses, unlike other pathogens, have a unique and intriguing relationship with human populations. Peter Medawar, who was awarded the Nobel Prize for medicine and physiology in 1960, described a virus as a piece of nucleic acid surrounded by bad news.[1] Their impact includes the ravages of smallpox and measles, brought to the New World by Europeans, which decimated the native populations, allowing the new settlers to invade and colonize without restraint. On the other hand, Europeans, including members of the military in the New World, died from yellow fever, especially the French forces in Haiti.[2] Around the same time, smallpox and measles viruses impacted on populations in Asia, the Middle East and Europe. Smallpox singularly killed an estimated 300 million individuals in the 20th century before its eradication.[3] Notwithstanding three worldwide pandemics of influenza occurred in the 20th century, in 1918, 1957, and 1968. The “Spanish” influenza pandemic of 1918–1919, which caused approximately 50 million deaths worldwide has been called the mother of all pandemics.[4] In the

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Mungrue K, Chattu VK. Poliomyelitis era in Trinidad from 1940 to 1972 and beyond: Implications for effective global health governance for its eradication. J Family Med Prim Care 2018;7:664-70.
latter part of the 20th century saw the emergence of HIV/AIDS, West Nile virus, Chikungunya, the threat of Ebola, and Zika.

From the viewpoint of medical history, poliomyelitis provides an intriguing and instructive case study. First, polio before the 19th century was a sporadic disease, which suddenly developed the ability to cause epidemics. Second, the application of two different vaccines – Inactivated Poliovirus vaccine (IPV) or Salk vaccine and Oral Polio Vaccine (OPV) or Sabin vaccine has resulted in dramatic reductions in paralytic poliomyelitis, constituting one of the most successful public health programs ever conducted on a global scale. Third, the “endgame” in polio eradication has offered some unexpected challenges that have delayed its global eradication.

Acute poliomyelitis (APM) is an infection caused by the poliovirus, a ribonucleic acid (RNA) virus of the enterovirus group of the Picornavirus family. The single-stranded RNA core is surrounded by a protein capsid without a lipid envelope, which makes poliovirus resistant to lipid solvents and stable at low pH. Three antigenically distinct strains are known, with Type I accounting for 85% of cases of paralytic illnesses. Infection with one type does not protect from the other types; however, immunity to each of the three strains is lifelong. Transmission occurs by close personal contact through the fecal–oral route. In the gastrointestinal tract, the virus is able of penetrating the mucosa through specialized microfold cells and replicate in underlying submucosal lymphoid tissues during the 1–3 weeks of the incubation period.

The virus may be secreted in saliva and feces during this period, causing most host-to-host transmission. After the initial alimentary phase, the virus drains into the cervical and mesenteric lymph nodes and then into the bloodstream to invade the central nervous system. Most poliovirus infections result in no illness or produce only self-limited symptoms, however, in approximately 5% of infected patients, the anterior horn cells of the spinal cord can be affected causing flaccid paralysis involving a single extremity to complete quadriplegia. The most serious complication of paralytic poliomyelitis is a respiratory failure from paralysis of the diaphragm and intercostal muscles due to the involvement of the motor centers of the brainstem (bulbar polio) and the spinal cord, which can lead to death.

Paralytic poliomyelitis epidemics first became known in the 19th century. However, historical records of the occurrence of prior sporadic outbreaks of paralytic poliomyelitis are controversial and a matter of disagreement. Notwithstanding, the great Scottish writer and poet, Sir Walter Scott, who was born in Edinburgh in 1771, developed an attack of fever in infancy that left him permanently lame, as he records: “I was discovered to be affected with the fever which often accompanies the cutting of large teeth. It held me 3 days. On the fourth, when they went to bathe me as usual, they discovered I had lost the power of my right leg.” In 1870, Charcot applied histological techniques to tissues obtained from patients with poliomyelitis, noting the shrinking and loss of substance in the anterior horn of the gray matter of the spinal cord an area containing the large motor neurons that control movement in the limbs. It is Charles Bell a Scottish physician attributed to be the first to record an epidemic of poliomyelitis depicting events in 1844 on the island of St. Helena. The disease’s striking presentation, in which previously healthy infants underwent an acute febrile illness followed by localized paralysis, would have made outbreaks conspicuous. However, few if any were reported until late in the 19th century. Beginning around 1880, an abrupt series of outbreaks of infantile paralysis were reported from several Scandinavian countries (Austria, Norway, and Sweden), Germany, England, and the United States but not in Canada, Cuba, or Brazil.

In the United States, beginning in the early 1900s, annual epidemics of poliomyelitis occurred with regularity until the introduction of the polio vaccine in 1955. In one such outbreak in 1921, Franklin Delano Roosevelt, a former President of the United States, to which a highway was named in his honor in Trinidad, was infected with the virus in his 14th year, emphasizing that white elites could be affected. His family recorded: “Below his waist, he cannot move at all. His legs have to be moved often as they ache when long in one position.” His subsequent contributions to polio included the creation of a National Foundation for Infantile Paralysis (now known as the March of Dimes) which raised money for the rehabilitation of victims of paralytic polio and was also instrumental in funding the development of the polio vaccine.

Inactivated polio vaccine (IPV) was introduced in 1955 and oral polio vaccine (OPV) in 1961, with significant effect. One such impact was the successful eradication of polio in Cuba the first country to successfully eradicate wild poliovirus and the dramatic reduction of cases in Brazil. Inspired by its effectiveness the Pan American Health Organization (PAHO) under the leadership of Dr. Ciro de Quadros undertook a vigorous immunization campaign with the goal of eradicating all wild polioviruses in the Americas. This resulted in the last case of endemic polio registered in Peru 1991. The aim of this study is to describe the historical impact of APM in Trinidad.

Methods

A retrospective analysis of all reported cases of APM occurring from 1939 to 1972 was undertaken. The data were derived from several sources. First, a review was conducted on available published studies, which appeared since 1935. The major source of these studies was obtained from the epidemiological publications of the League of Nations Health Organization, the World Health Organization, and other studies. To track the occurrence of APM in Trinidad both before and after the 1972 epidemic, data were obtained from the Annual Statistical Reports published by the Ministry of Health, from 1972 to 2000. In compliance with the regional polio elimination strategies, Latin American and Caribbean (LAC) countries must report and investigate all cases of acute flaccid paralysis (AFP)
Mungrue and Chattu: Poliomyelitis in Trinidad from 1940 to 1972 and beyond: Implications for effective global health governance

in children aged <15 years. AFP is formally defined in LAC as any flaccid paralysis with acute onset for any reason other than severe trauma.[28,29] The LAC countries also use standardized definitions for polio and clinical and laboratory criteria for the disease's differential diagnosis. A stool specimen is required to test for poliovirus.[30–33] Simple univariate statistics were used. We report mainly counts of disease occurrence and deaths and were applicable rates.

Results

Trinidad experienced a similar epidemiological pattern of occurrence of APM as other countries. The earliest recorded occurrence of poliomyelitis in Trinidad was in 1939. Between 1939 and 1953, the number of notifications had as a rule never exceeded 10 per annum, with the exception of 1941 (59 cases), and 1942 (150 cases) [Figure 1].

Hence, there were either two small outbreaks in 1941 and 1942, or there was one epidemic, which started in 1941 and ended in 1942 with an intermittent type epidemic curve. The data to distinguish between the two are unavailable. Subsequently, there was another outbreak in 1954 consisting of 189 cases and one death the largest ever outbreak occurring in Trinidad. While there were sporadic cases between 1955 and 1971, there were no epidemics. In the 1954 outbreak, the majority of cases occurred between July and September with a maximum (53) in August. Males were, as usual, more affected than females (109 vs. 80). The predominant age group affected was 0–4 years (64%), as shown in Table 1.

After a break of 16 years suddenly in 1971 poliomyelitis reemerged. The onset of the outbreak began with a case on November 4, 1971, and by January 1972 it reached its peak with 127 reported cases. Thereafter, it began to decline. A total of 181 cases were observed and there were 12 deaths, resulting in a case fatality rate of 6.6%. Eleven of these were in the age group 0–10 years, resulting in an age-specific mortality rate of 8/100,000 population and one was aged 21. The majority of cases (157, 87%) were aged 10 and under and 92% were under 15 years of age. The Type 1 virus was the organism responsible and this was confirmed by virus isolation in 97 (54%) cases. The overwhelming majority (93%) of the cases were inadequately immunized, while 7% gave dubious histories of immunization. Subsequently, a mass immunization drive was undertaken in January and February 1972, which succeeded in immunizing 81% of children 0–6 years and 84.9% of those 7–12 years of age. There were no cases reported from Tobago. In 1954, TTO recorded its highest birth rate ever 41.9/1000, while in 1972, the birth rate was 26.3/1000. The average birth rate between 1969 and 1971 was 24.5/1000.

Discussion

The findings of this study confirm that in the history of Trinidad and Tobago there were three outbreaks of APM in the 20th century. Historical data, particularly in prevaccine periods without a high degree of human intervention, offer a unique glimpse into the ecology of infection.[34] Thus, an important finding was in earlier outbreaks the predominant age group was 0–4 years by 1972, the predominant age groups were 1–10 years and >11–15 years. This finding supports the proposition that the emergence of epidemic poliomyelitis in the western world is interlinked with progressive urbanization and improving sanitary standards that delay the age of infection beyond infancy as well as the protection of passively acquired maternal antibodies.[35] Age has also been known to influence the clinical manifestations and severity of poliomyelitis infection. Reviews of cohorts of polio patients in the 1950s showed that people aged ≥15 years of age had an increased rate of bulbospinal paralysis, the most severe form of poliomyelitis.[36–38] Other studies demonstrated increased mortality due to respiratory muscle paralysis and secondary complications of polio among older polio patients.[39,40]

We observed a periodicity of the epidemics, the first spanning 11 years (1943–1953) and the other 17 years. (1955–1971). During both epidemics, the birth rate was at there highest supporting the proposition that demographic changes may have a role in infectious disease epidemiology.[41,42] The rate of susceptible recruitment has long been known to control the magnitude

Table 1: The distribution of acute poliomyelitis cases by age and gender 1971-72

| Age (years) | Male, n (%) | Female, n (%) | All cases, n (%) |
|------------|-------------|---------------|-----------------|
| <1         | 20 (18.3)   | 21 (26.1)     | 41 (21.7)       |
| 1-4        | 50 (45.9)   | 30 (37.5)     | 80 (42.3)       |
| 5-9        | 10 (9.2)    | 11 (13.8)     | 21 (11.1)       |
| 10-19      | 18 (16.5)   | 11 (13.8)     | 29 (15.3)       |
| 20-39      | 9 (8.3)     | 7 (8.8)       | 16 (8.5)        |
| >40        | 2 (1.8)     | 0             | 2 (1.1)         |
| Total      | 109 (100)   | 80 (100)      | 189 (100)       |
and frequency of epidemics of fully immunizing childhood diseases.\[44,46\] Although no single theory has proved satisfactory, three explanations have been advanced: pathogen appearance and disappearance, environmental changes, and host-behavior changes.

The other important finding was OPV was available well before the 1972 outbreak. It is well established that the development of vaccines to combat infectious diseases initiated over 200 years ago is the most significant discovery in the history of preventive medicine. However, did the balance between its cost, benefits, and risks all of which apply to the polio vaccine prevent its aggressive implementation. Trivalent OPV was introduced in 1963, i.e., 9 years before the 1972 outbreak and by the beginning of the 1970's polio was already eradicated from Cuba. The ease of oral administration of the OPV as opposed to intramuscular injection IPV, induction of mucosal immunity, and the public health benefit of the spread of live vaccine viruses from immunized to unimmunized contacts made the OPV popular. Following the 1972 outbreak 1 year later, the immunization of children became mandatory through the enactment of Public Health Nursery Schools and Primary Schools Immunization Act, Chapter 28:03 of 1973. The act prescribes that all children be immunized against poliomyelitis, diphtheria, tetanus, measles, and yellow fever, as a legal requirement for school entry. In May 1974, the World Health Assembly (WHA) created the Expanded Program on Immunization, to achieve the goal of immunizing by 1990 all children under 5 years of age against six vaccine-preventable diseases: diphtheria, tetanus, pertussis, measles, tuberculosis, and polio.

Subsequently in May 1985, the Ministers of Health of the region, through PAHO/WHO, announced the goal of eradication of the wild poliovirus from the Americas by 1990. LAC, as well as Canada and the United States, interrupted the indigenous transmission of wild poliovirus in 1991. The last case of poliomyelitis in the Americas occurred in Peru in 1991 and the Americas were certified polio-free in September 1994. In 1988, as a result of the progress made in the Americas, the WHA established the goal of eradicating polio by 2000 and in 2000 declared global polio eradication a public health emergency; at the time, it was endemic in 125 countries. Although the last case of polio in TTO was in 1972, in other continents, polio continued beyond 2000. This has forced the WHO to develop the Polio Eradication Endgame Strategic Plan 2013–2018 which inter alia recommended that by April 2016 the polio vaccine should be switched from the trivalent OPV (tOPV) to the bivalent OPV and the Inactivated Polio Vaccine against cVDP2. The Ministry of Health in TTO declared April 26, 2016 as the “National Switch Day,” an internationally synchronized event, where health workers in every health facility will conduct the switching of the vaccine, disposing of all tOPV2 vials.

Notwithstanding all the efforts, some obstacles to eradication lie outside the realm of biology or medicine. They include military conflicts, cultural, and political misinformation about the safety of the vaccine and access to remote communities through difficult terrain. Even now on the African continent, the battle rages on 20 years after Nelson Mandela launched the pan-African “kick polio out of Africa” campaign. In March of 2017, to tackle the last remaining stronghold of polio on the continent, 190,000 polio vaccinators in 13 countries across west and central Africa will immunize >116 million children under 5 years of age.\[47\]

The limitations of this study are likely related to the sensitivity of AFP surveillance to detect cases, the potential of misclassification of cases, and underreporting of cases. Much has been learned about the virus that causes this dreaded disease; however, the end is not clearly in sight. If and when eradication of APM occurs, several important questions will arise. Do we need vaccination after wild poliovirus circulation has been stopped? If so, what vaccine is optimal for posteradication immunization programs? How could polio vaccines be improved and made more safe, efficacious, cheaper, and easier to deliver? These questions present a conundrum in that continued use OPV can lead to the emergence of vaccine-derived polioviruses that will inevitably lead to outbreaks. On the other hand, withdrawal of OPV will also cause immunologically susceptible populations to develop that can fuel the spread of outbreaks following reintroduction of the virus. Reintroduction can occur through accidental release from research or vaccine manufacturing facilities or acts of bioterrorism by synthetic virulent poliovirus.\[48\]

The eradication of polio in the near future will not mean an end to the long-term consequences of the disease. These include continued support to those disabled and awareness of the postpolio syndrome (PPS).\[49\] The exact prevalence of PPS worldwide is unknown, but it is estimated that it can affect as much as 25%–40% of all polio survivors. Clinically, after years or decades of stability (most commonly up to three decades after initial infection), polio victims begin to experience new or worsening disabling symptoms as they age. Although the cause of the denervation is unknown, common symptoms include muscle and joint weakness, pain, fatigue, muscle atrophy, difficulty breathing, and swallowing.

**Polio eradication and various global health governance initiatives**

APM/polio has brought together international agencies, government, and the people to build an effective public health system around a common vision for health and wellbeing, through cooperation, support, and sufficient funding. It has contributed to the emergence of grassroots fund-raising campaigns that would revolutionize medical philanthropy, the rise of rehabilitation therapy, spurred campaigns for the social and civil rights of the disabled, and enactment of laws to preventing spitting in public places still an our statuary books, the public health ordinance Ch. 12 No 4 of 1952. Over the past
quarter-century, the US $9.5 billion has already been spent on polio eradication, driven by international organizations primarily the WHO and United Nations Children’s Fund (UNICEF) as well as private donors like Bill and Melinda Gates Foundation and Rotary International. The WHO’s strategic advisory group of experts on immunization have said that failure to eradicate polio would be “the most expensive public health failure in history.” The Polio Eradication and End Game strategic Plan (2013–18) represents a major milestone in polio eradication which was developed by Global Polio Eradication Initiative (GPEI) in consultation with all stakeholders (national health authorities, scientific experts, Global Alliance for Vaccines and Immunization Alliance, donors, etc.) and has four objectives, namely, virus detection and interruption, routine immunization strengthening and OPV withdrawal, containment and certification, and legacy planning.[50]

Global polio eradication initiative
GPEI housed at the WHO aims to eradicate polio by 2019. It is one of the most ambitious and wide-reaching global health initiatives with an annual budget of US $1 billion and has reduced polio cases by 99% globally.[51] The GPEI includes the WHO, UNICEF, the US Centers for Disease Control, and Rotary International as spearheading partners which make all decisions about the polio program. If we look back to 1988, the WHA’s original goal was to eradicate polio by 2000 and that milestone was missed and so were the next several although the cases decreased significantly. The GPEI was created after the resolution from WHA was approved.

In 2007, the Bill and Melinda Gates Foundation announced that it would contribute $100 million toward the eradication of polio with an ambitious thought of eradicating polio within 5 years. Within the next few years, the polio program budget reached a steady state of $1 billion a year, but the program was still being governed by the four original spearheading partners. This is an unusual governance dynamic, as these four organizations were implementing the work, managing the budget, and also overseeing their program.

Shortfalls in global polio eradication initiative
The donors who contributed the funding and the countries where the work was being performed had no formal say in the program’s overall governance. Major funders of the polio program, including the United States, the United Kingdom, and the Gates Foundation, pushed for stronger governance and a number of new entities were created. The first is the Polio Oversight Board, which includes leaders from the original four spearheading partners plus the Gates Foundation meets quarterly with the defined goals of providing operational oversight and high-level accountability across the GPEI partnership. Unfortunately, this oversight board still has the same governance challenge of the previous mechanism, as the board is only comprised of five organizations who are heavily involved in the day-to-day execution of the program.

The second new entity is the Global Polio Partners Group (PPG). The PPG serves as a stakeholders’ voice for the GPEI and reports the results to the Polio Oversight Board. The addition of this group has expanded the input given to polio decision-makers. It includes a wide range of organizations who are involved in polio, including donor and endemic country governments. However, the group is somewhat informal in nature and its recommendations are nonbinding.

A third group that was established was the Independent Monitoring Board (IMB). While this group is funded out of the GPEI budget, it operates independently and issues regular reports with very candid assessments of GPEI’s progress toward eradicating polio and advises on changes that the program needs to make. While the IMB has been a big improvement in transparency and independence in the polio governance landscape, its mandate is limited only to certain GPEI activities. Moreover, it has no authority to make changes and only provides recommendations.

Conclusions
The direct consequences of eradication will include the prevention every year of thousands of deaths and permanent paralysis of hundreds of thousands of people, especially children.[52] This will yield up to at least US$ 25 billion in net benefits over the next 20 years. In summary, in this journey of achieving the goal of eradication of polio from the globe, these additional governance mechanisms have certainly strengthened and broadened the participation and oversight of the polio program. The role of global health diplomacy is enormous in bringing all the stakeholders together, have successful negotiations to ensure adequate funding and commitment by all partners to eradicate globally. The governance of GPEI would still benefit from adopting some of the best practices in governance from other organizations in the global health sector.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

References
1. Medawar PB, Medawar JS. Aristotle to Zoos. Cambridge: Mass: Harvard University Press;1983.
2. Malone D. Jefferson the President: First Term 1801–1805. Boston: University of Virginia Press;1970.
3. Henderson DA. Smallpox eradication. In: Koprowski H, Oldstone MB, editors. Microbe Hunters Past and Present. Bloomington, IN: Medi-Ed Press;1996. p. 39-43.
4. Taubenberger JK, Morens DM. 1918 influenza: The mother of all pandemics. Emerg Infect Dis 2006;12:15-22.
5. Salk JE, Krech U, Youngner JS, Bennett BL, Lewis LJ, Bazeley PL, et al. Formaldehyde treatment and safety testing of experimental poliomyelitis vaccines. Am J Public Health
6. Sabin AB. Present position of immunization against poliomyelitis with live virus vaccines. Br Med J 1959;1:663-80.
7. Centers for Disease Control and Prevention (CDC). Progress towards interruption of wild poliomyelitis transmission worldwide. Wkly Epidemiol Rec 2010;85:178-84.
8. Iwasaki A, Welker R, Mueller S, Linehan M, Nomoto A, Wimmer E, et al. Immunofluorescence analysis of poliovirus receptor expression in Peyer's patches of humans, primates, and CD155 transgenic mice: Implications for poliovirus infection. J Infect Dis 2002;186:585-92.
9. Paul JR. A History of Poliomyelitis. New Haven, CT: Yale University Press; 1971.
10. Koprowski H. Avisitto ancient history. In: Koprowski H, Oldstone MB, editors. Microbe Hunters Past and Present. Bloomingtn, IL: Medi-Ed Press; 1996. p. 141-52.
11. J. M. Charcot. Lectures on the Diseases of the Nervous System. London, 1881. Rpt. New York, 1962.
12. Bell C. The Nervous System of the Human Body as Explained in a Series of Papers Read Before the Royal Society of London. London; 1844.
13. Ward G. A First Class Temperament: The Emergence of Franklin D. Roosevelt. New York: Harper & Row; 1989.
14. Rodriguez Cruz R. Mass polio vaccination program, 1962-1982. Rev Infect Dis 1984;6 Suppl 2:s408-12.
15. Baptista Risi J Jr. The control of poliomyelitis in Brazil. Rev Infect Dis 1984;6 Suppl 6:400-3.
16. Freyche MJ. World Health Organization. Epidem Vital Statist Rep 1950;3:33.
17. Freyche MJ. World Health Organization. Epidem Vital Statist Rep 1952;5:145.
18. Freyche MJ, Nielsen J. Incidence of Poliomyelitis since 1950. In: Poliomyelitis. World Health Organization: Monograph Series, No. 26. Geneva; 1955. p. 59.
19. Freyche MJ, Payne AM, Lederrey C. Poliomyelitis in 1953. Bull World Health Organ. 1955;12:595-649.
20. There is no author. Its a weekly report of League of Nations Health Organization. League of Nations, Health Organization. Wkly Epidem Rec 1937;12:451.
21. There is no author. Its a weekly report of League of Nations Health Organization. League of Nations, Health Organization. Wkly Epidem Rec 1938;13:458.
22. League of Nations, Health Organization. Wkly Epidem Rec 1939;14:494.
23. League of Nations, Health Organisation. Wkly Epidem Rec 1942;17:246.
24. World Health Organization. Epidem vital Statist Rep 1951;4:2.
25. World Health Organization. Epidem Vital Statist Rep 1953;6:87.
26. World Health Organization. Annual Epidemiological and Vital Statistics. Geneva: World Health Organization; 1950.
27. Pan American Health Organization (PAHO). Polio Eradication Field Guide, no. 40. 2nd ed. Washington, DC: PAHO; 1994.
28. Pan American Health Organization (PAHO). Poliomyelitis Eradication Field Guide, no. 607. 3rd ed. Washington, DC: PAHO; 2006.
29. Siung OH. The 1971-1972 poliomyelitis epidemic in Trinidad. WIMJ 1972;21:169.
30. Landaverde JM, Danovaro-Holliday MC, Trumbo SP, Pacis-Tirso CL, Ruiz-Matus C. Guillain-barré syndrome in children aged <15 years in Latin America and the Caribbean: Baseline rates in the context of the influenza A (H1N1) pandemic. J Infect Dis 2010;201:746-50.
31. World Health Organization (WHO). Progress towards interruption of wild poliomyelitis transmission worldwide. Wkly Epidemiol Rec 2010;85:178-84. Available: from http://www.who.int/who/er/2010/10/08520.pdf?ua=1. [Last accessed on 2018 Jul 15].
32. Nathanson N, Martin JR. The epidemiology of poliomyelitis: Enigmas surrounding its appearance, epidemicticy, and disappearance. Am J Epidemiol 1978;110:672-92.
33. Andrus JK, Strebel PM, de Quadros CA, Olivé JM. Risk of vaccine-associated paralytic poliomyelitis in Latin America, 1989-1991. Bull World Health Organ 1995;73:33-40.
34. Weinstein L. Influence of age and sex on susceptibility and clinical manifestations in poliomyelitis. N Engl J Med 1957;257:47-52.
35. Ferris BG, Auld PA, Cronkhite L, Kaufmann HJ, Kearsley RB, Prizer M, et al. Life-threatening poliomyelitis. N Engl J Med 1960;262:371-80.
36. Weinstein L, Shelokov A, Seltser R, Winchell GD. A comparison of the clinical features of poliomyelitis in adults and in children. N Engl J Med 1952;246:297-302.
37. Smith E, Harris II, Rosenblatt P. Acute poliomyelitis; a clinical and statistical study of 263 cases. J Pediatr 1953;43:9-20.
38. Baker AB, Matzke HA, Brown JR. Bulbar poliomyelitis; a study of medullary function. Arch Neurol Psychiatry 1950;63:257-81.
39. Fox MJ, Kuzma JF, Junkerman CL. Bulbar poliomyelitis. N Engl J Med 1952;247:276-9.
40. Kelleher WH. Diagnosis and treatment of bulbar poliomyelitis. Lancet 1951;1:973-7.
41. Nicholls EE. Poliomyelitis; a study of 320 cases. Pa Med J 1950;53:1278-82.
42. Horstmann DM. Poliomyelitis: Severity and type of disease in different age groups. Ann N Y Acad Sci 1955;61:956-67.
43. Olin G, Fishbein M. The epidemiologic pattern of poliomyelitis in Sweden from 1905 to 1950, 1952. Poliomyelitis: Papers and Discussions Presented at the Second International Poliomyelitis Conference. Philadelphia, PA: JB Lippincott & Company; 1952. p. 367-75.
44. Earn DJ, Rohani P, Bolker BM, Grenfell BT. A simple model for complex dynamical transitions in epidemics. Science 2000;287:667-70. Available: from: http://www.ncbi.nlm.nih.gov/pubmed/10650003. [Last accessed on 2017 Oct 12]
45. Morris SE, Pitzer VE, Viboud C, Metcalf CJ, Bjornstad ON, Grenfell BT, et al. Demographic buffering: Titrating the effects of birth rate and imperfect immunity on epidemic dynamics. J R Soc Interface 2015;12:20141245.
46. Brouin H, Viboud C, Grenfell BT, Miller M, Rohani P. Impact of vaccination and birth rate on the epidemiology of pertussis: A comparative study in 64 countries. Proc R Soc Biol Sci 2010;277:3239-45. Available: from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2981935 &tool=pmcentrez&rendertype=abstract. [Last accessed on 2017 Jul 18].
47. WHO. From Coast to Coast: Africa Unites to Tackle Threat of Polio, Joint News Release UNICEF/WHO; 2017. Available: from: http://www.who.int. [Last accessed on 2017 Jul 18].
48. Cello J, Paul AV, Wimmer E. Chemical synthesis of poliovirus
cDNA: Generation of infectious virus in the absence of natural template. Science 2002;297:1016-8.

49. Bakker M, Schipper K, Koopman FS, Nollet F, Abma TA. Experiences and perspectives of patients with post-polio syndrome and therapists with exercise and cognitive behavioural therapy. BMC Neurol 2016;16:23.

50. WHO. About the Polio Endgame Strategic Plan. Available from: http://www.who.int/immunization/diseases/poliomyelitis/endgame_objective2/about/en/. [Last accessed on 2017 Oct 20].

51. WHO, Polio Eradication & Endgame Strategic Plan 2013-2018 Document by WHO, Rotary, CDC and UNICEF; 2013. Available from: http://www.polioeradication.org/wp-content/uploads/2016/07/PEESP_EN_A4.pdf. [Last accessed on 2017 Oct 20].

52. Polio Eradication: Overcoming the Final Barriers and Ensuring a Lasting Legacy for Health Systems, Graduate Institute, Geneva; 2016. Available from: https://www.med.uio.no/helsam/english/research/centres/global-health/news-and-events/events/2016/flyer_zf_polio_v7.pdf. [Last accessed on 2017 Oct 20].