



# The Epidemiology of Poliomyelitis Deconstructed

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Polio is widely considered as one of the most terrifying diseases to ever strike at humanity. Polio often struck without warning and left lifelong pain and suffering. Thousands of people were left either dead or worse paralyzed for life with small hopes of regaining normal lives. The first widely recognized epidemics of Polio first appeared in North America and European nations in the late 19th century, following which Polio became a global pandemic(Nathanson). Fortunately, the terror of Polio was only able to persist for so long before it was defeated by medical science. Polio is a deadly disease that cripples the lives of those that it attacks.

Polio is an acute infectious disease that is caused by an enterovirus of the Picornaviridae family (CDC Pinkbook). The Poliovirus invades its host's central nervous system and destroys lower motor neurons causing paralysis (CDC Pinkbook). Polio is mainly transmitted from person to person by ingestion of contaminated fecal matter, contaminated water or oral contact with an infected individual's secretions (CDC Pinkbook). The incubation period for Polio is commonly 6 to 20 days (CDC Pinkbook). The Polio virus is comprised of single stranded RNA with a protein capsid (CDC Pinkbook). There are three known types of Polio, P1, P2, P3 and they are all very distinct in their risk to cause paralysis (CDC Pinkbook). The risk of contracting paralysis is the highest if one is exposed to P3, but on the other hand P1 accounts for 79% of all Polio paralysis cases (Nathanson Table 1). All the types of Polio are limited to only infecting humans (Nathanson). Therefore, there are no known nonhuman reservoirs (Nathanson). These are but a few characteristics of the virus that causes Polio.

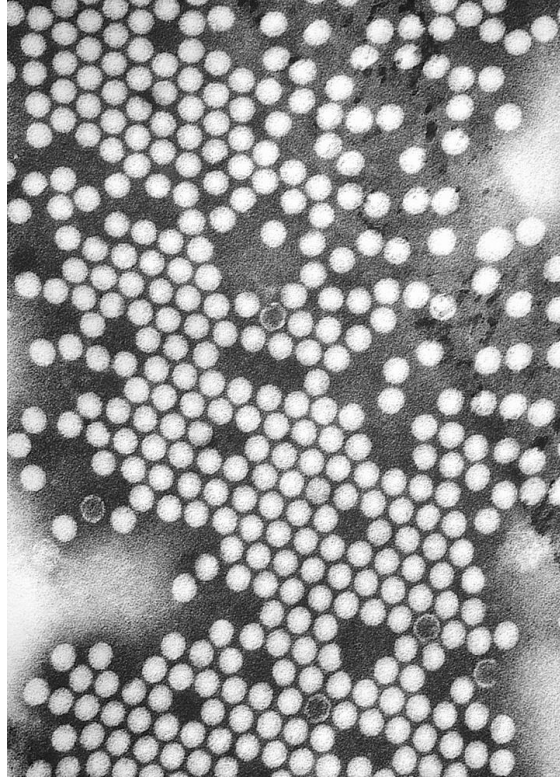


Figure 1: Electron Micrographs of Polioviruses

Polio has a wide spectrum of symptoms in which it can manifest itself. However, Polio is typically characterized for its ability to cause paralysis. The death rate for paralytic Polio is 2-5% in children, up to 30% for adults (CDC Pinkbook). The ratio of paralysis in individuals exposed to Polio can vary immensely; it either is 50 to 1, 1000 to 1, but it is usually 200 to 1 (CDC Pinkbook). Out of 200 people that are exposed to Polio one person is paralyzed in the stage of clinical disease (CDC Pinkbook). Polio is classified on the severity that it presents itself and can be commonly mistaken for other illnesses such as the Flu due to its symptoms. However, most cases of Polio are subclinical meaning the disease is not severe enough to cause any observable symptoms (CDC Pinkbook). 95% of Polio infections will be asymptomatic meaning there will be no signs of symptoms that may hint illness (Nathanson). 4 to 8 % of Polio infections will consist of minor nonspecific illness known as abortive Polio (CDC Pinkbook). A person with abortive

Polio may develop upper respiratory tract infections, fever, a sore throat, nausea, vomiting, abdominal pain and diarrhea which all mimic other diseases (CDC Pinkbook). Less than 1% of all Polio infections will result in flaccid paralysis (CDC Pinkbook). A person with flaccid paralysis can have a loss of reflexes, severe muscle aches, spasms in the limbs and back. Paralytic Polio is divided into three subcategories, spinal Polio which accounts for 79% of all cases, brainstem infection which is 2% of cases, and brain and spinal polio which is 19% of cases (CDC Pinkbook). The mortality rate for Polio only applies to paralytic Polio and is 2-5% in children and up to 30% on average for adults (CDC Pinkbook). Polio can manifest itself in a huge variety of methods.

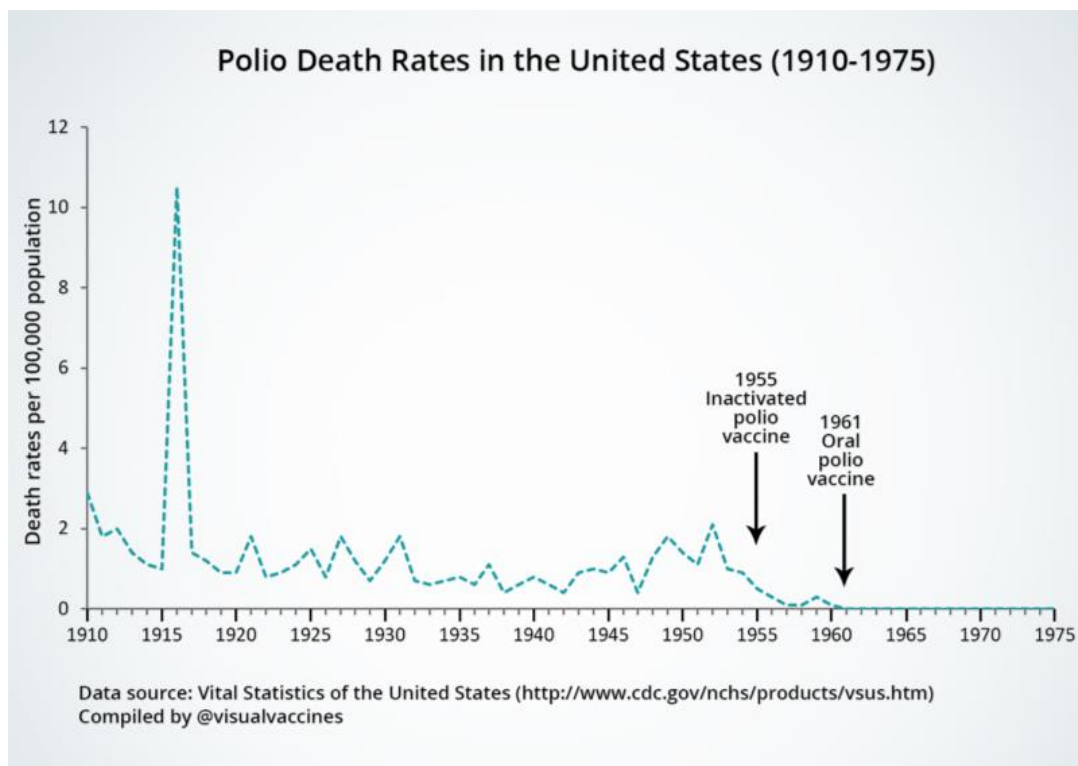


Figure 2: Death Rates From Polio in the United States from 1910-75

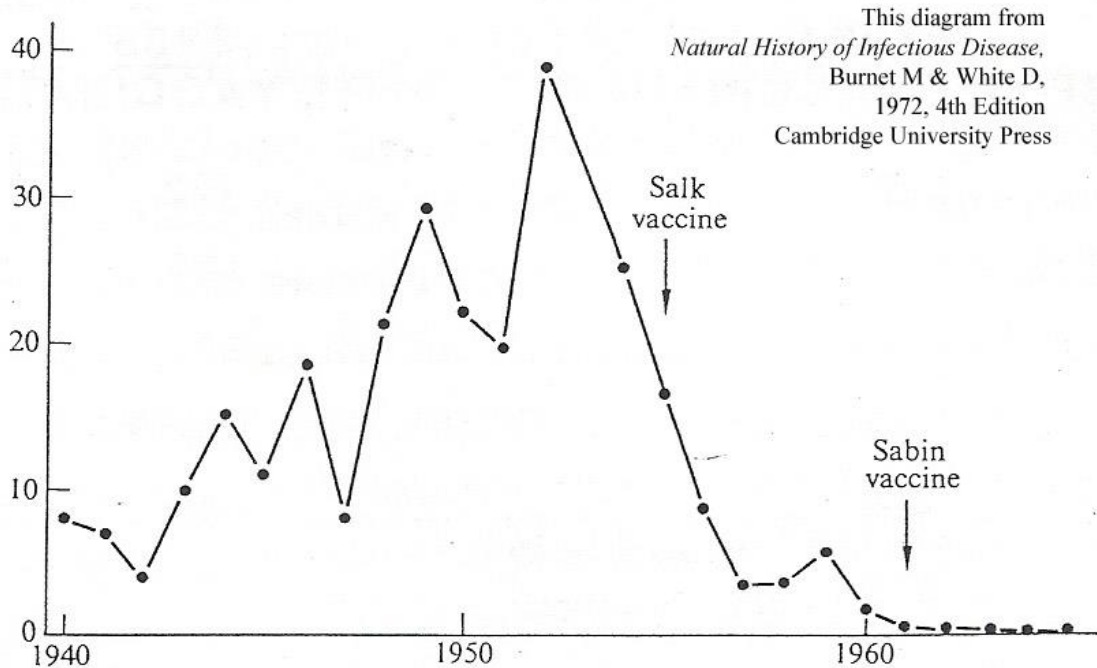
Public statistics about Polio are very interesting. Currently, there are no cases of Polio anywhere, except in three countries: Nigeria, Afghanistan and Pakistan (Poliomyelitis). The



incidence of Polio has dropped about 99% since the launch of the Polio global eradication program in 1988(Poliomyelitis).Cases of Polio are relatively rare now so it is difficult to find them. The prevalence for Polio was only 125 cases out of all countries in 2014(Poliomyelitis.)It is a good thing that Polio has been eradicated because the transmission rate for Polio is incredibly high. There is nearly 100% chance of transmission among susceptible children and 90% transmission risk to adults (CDC Pinkbook). As evidence of the severity of Polio infections in children from 1912 to 1919 Massachusetts more than 60% of Polio cases were in children under 10(Nathanson) The prevalence rate of Polio was 35,000 cases at its peak in the 20<sup>th</sup> century in the United States (CDC Faqs). Additionally, at its height from 1950–1954 the incidence rate of poliomyelitis was the equivalent to an average annual rate of 14.6 per 100,000 persons (Trevelyan). Outside of the United States the rate of Polio infection was a staggering 350,000 cases worldwide in 1988 (Polomyelitis). Polio has ravaged the lives of many people.

## The Incidence of Polio from 1940-1965 in the United States

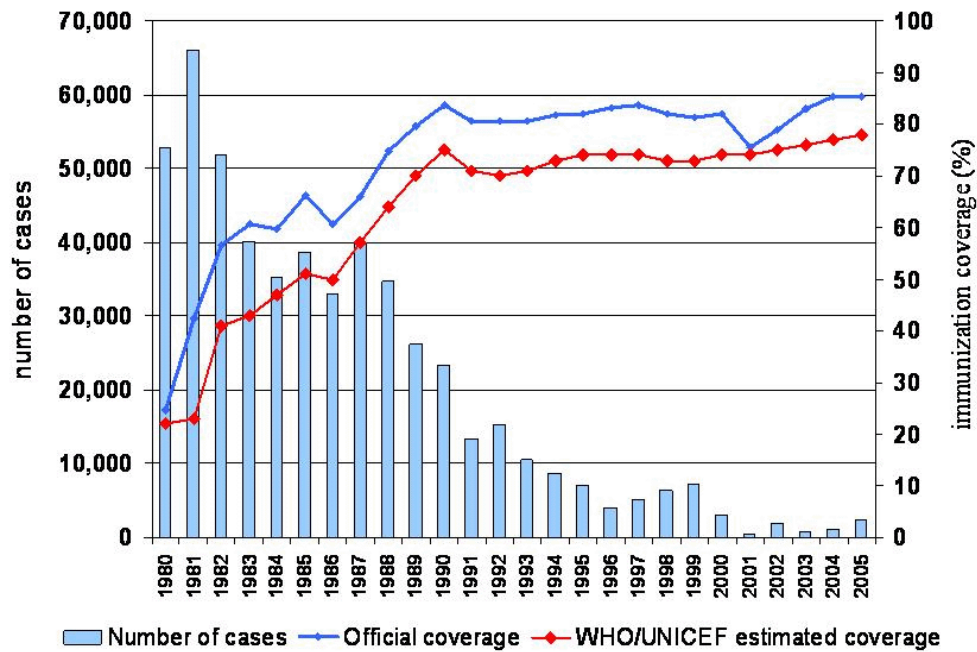
Poliomyelitis in the United States, 1940-65. Annual incidence per 100,000 population. (Redrawn from J. R. Paul, 1971.)



The descriptive epidemiology of Polio is unique. Firstly, the gender and race of people have no real significance on the risk of contracting Polio. Anyone is susceptible to contracting Polio. Secondly, children are the most vulnerable group of people to Polio (CDC Faqs, CDC Pinkbook). Third, Polio is suspected to be a seasonal disease in temporal zones (Nathanson). Polio cases seem to thrive in environments with high temperatures and humidity ((Nathanson). In New England, Polio cases were found to be increasing from August to September as humidity exceeded 40% and declined as temperature dropped in the winter (Nathanson). In another analysis of seasonality affecting, Polio cases Hawaiian Polio cases stayed relatively consistent or actually increased as long as the rate of humidity was high(Nathanson).Finally, geographically

Polio cases seem to occur in countries with poor sanitation and vaccination programs such as Afghanistan, Nigeria and Pakistan. Polio is quite distinct.

Poliomyelitis global annual reported incidence and POL3 coverage, 1980-2005



Source: WHO/IVB database, 2006  
Slide date: 11 September 2006



Figure 3: Report of Incidence of Polio Cases Globally Conducted By WHO

There are several analytical aspects to Polio that must be known. There are non-modifiable risk factors involved. For instance, the immune-compromised are more at risk of contracting type 2 Polio while those whose health is well are most at risk from type 3 Polio (Nathanson). Although, there is no evidence to suggest that genes play any role in Polio transmission. Race, sex and gender do not contribute to Polio contraction or transmission. There are studies that have identified risk factors that one could modify to better protect themselves. According to epidemiologists Neal Nathanson and Olen M. N on their paper, “The Epidemiology



of Poliomyelitis Deconstructed” transmission of Polio depends on immunization gaps, the intensities of environmental risks such as population density and sanitation (Nathanson). Although this may be difficult for some, but a person could easily improve their immunity towards Polio by taking vaccines, perhaps move away from dense population areas and improve their own hygiene. In contrast to Neal and Olean, another group of epidemiologists Barry Trevelyan, Andrew Cliff and Matthew Raynor suggested that reduction of maternal antibodies may have influenced a loss of protection against Polioviruses (Trevelyan). It seems that Trevelyan and his fellow researchers are suggesting that maybe there was a reduction in behavior that provided immunity and a loss of ‘maternal antibodies. A person could protect themselves from Polio by engaging in behavior that encourages immunity.

There are several effective screening methods for Polio. However, they seem to face many problems. For the global eradication campaign for Polio surveillance of acute flaccid paralysis was a very frequently used method to find Polio cases (Andrus and J.M). Diagnosis of acute flaccid paralysis was determined by matching with criterion such as fever at the onset of paralysis or complete paralysis (Andrus and J.M). Diagnoses of acute flaccid paralysis often had varying degrees of specificity or sensitivity depending on symptoms matching that of paralysis or when symptoms were measured (Andrus and J.M). There was approximately 96% sensitivity and 49% specificity when a 4 day or more complete development of paralysis was measured (Andrus and J.M). On the other hand there was about sbhardwaj@ucmerced.edu73% specificity and 75% sensitivity when fever was measured at the onset of paralysis (Andrus and J.M). Stool sampling alongside flaccid paralysis surveillance is another commonly tool used for diagnosis of Polio (Herremans). Stool sampling unfortunately faces many problems as well. Timely collection of stool samples from patients with suspected cases of paralysis makes a huge difference and this





requirement is not always met (Herremans). In a demonstration of stool sampling a study conducted an experiment where 69 patients with Polio and 86 of their family members were examined for poliovirus excretion (Herremans). The researchers found a high positivity rate of about 94%, sensitivity values of 83, 88%89% and positive predictive values of 76%, 67% and 56%. The significance of the study was polioviruses were being increasingly difficult to isolate as time passed on, and therefore it was necessary to change the approach of diagnosing polio (Herremans). The various forms of screening had a lot of difference because of how they were measured.

Preventing Polio is primarily done through primary prevention. Primary prevention prevents new disease by reducing risk factors. Primary prevention tries to prevent a specific condition. The tool that is traditionally used to prevent Polio is a vaccine (CDC Pinkbook). Vaccines are easy to administer and are highly cost effective (CDC Pinkbook). Secondary screening for Polio doesn't work because most people don't show signs of having Polio if they do have it, and most people do not develop any complications. Tertiary prevention does not work either because if a person has the most severe complications of Polio then there is a very limited scope of options doctors can utilize. Therefore, Primary prevention through vaccines is the most effective method of prevention.





## References

- Andrus, J. K., C. De Quadros, J. M. Olivé, and H. F. Hull. "Screening of Cases of Acute Flaccid Paralysis for Poliomyelitis Eradication: Ways to Improve Specificity." *Bulletin of the World Health Organization*. World Health Organization, n.d. Web. 08 May 2015. <<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2393371/?page=1>>.
- Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 07 May 2012. Web. 08 May 2015. <<http://www.cdc.gov/vaccines/pubs/pinkbook/polio.html>>.
- Centers for Disease Control and Prevention*. Centers for Disease Control and Prevention, 11 Aug. 2014. Web. 08 May 2015. <<http://www.cdc.gov/vaccines/vpd-vac/polio/dis-faqs.htm>>.
- Herremans, Tineke, and Marion Koopmans. "Lessons from Diagnostic Investigations of Patients with Poliomyelitis and Their Direct Contacts for the Present Surveillance of Acute Flaccid Paralysis." (n.d.): n. pag. Web. 8 May 2015. <[http://www.researchgate.net/profile/Marion\\_Koopmans/publication/12711251\\_Lessons\\_from\\_diagnostic\\_investigations\\_of\\_patients\\_with\\_poliomyelitis\\_and\\_their\\_direct\\_contacts\\_for\\_the\\_present\\_surveillance\\_of\\_acute\\_flaccid\\_paralysis/links/09e4150dc39db2edf200000.pdf](http://www.researchgate.net/profile/Marion_Koopmans/publication/12711251_Lessons_from_diagnostic_investigations_of_patients_with_poliomyelitis_and_their_direct_contacts_for_the_present_surveillance_of_acute_flaccid_paralysis/links/09e4150dc39db2edf200000.pdf)>.
- Nathanson, Neal, and Olen M. Kew. "From Emergence to Eradication: The Epidemiology of Poliomyelitis Deconstructed." *American Journal of Epidemiology*. Oxford University Press, n.d. Web. 08 May 2015. <<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2991634/>>.
- "Poliomyelitis." *WHO*. N.p., n.d. Web. 08 May 2015. <<http://www.who.int/mediacentre/factsheets/fs114/en/>>.



Trevelyan, Barry, Matthew Smallman-Raynor, and Andrew D. Cliff. "The Spatial Dynamics of Poliomyelitis in the United States: From Epidemic Emergence to Vaccine-Induced Retreat, 1910–1971." *Annals of the Association of American Geographers*. Association of American Geographers. U.S. National Library of Medicine, n.d. Web. 08 May 2015. <<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1473032/>>.