

## Poliovirus

### Summary

Poliovirus, or polio, has caused epidemics for centuries. Although highly contagious and notorious for causing paralysis, less than 1% of all poliovirus infections in children result in flaccid paralysis; most infections result in no or mild cold-like symptoms. The detection of a single paralytic case therefore indicates that there are likely many more undetected, nonparalytic polio infections.

Polio infections in the United States peaked in 1952, with >21,000 paralytic cases. Following introduction of inactivated polio vaccine in 1955, and oral polio vaccine in 1961, polio incidence plummeted. The last case of wild poliovirus acquired in the United States occurred in 1979. Two of the three serotypes of wild poliovirus (types 2 and 3) have been eradicated worldwide, and endemic circulation of type 1 wild poliovirus remains only in difficult-to-vaccinate regions of Pakistan and Afghanistan (at the time of writing).

However, polio outbreaks continue across the globe due to wild poliovirus, weakened vaccine-type poliovirus in susceptible persons exposed to oral polio vaccine (OPV), and vaccine-derived poliovirus, in which the weakened vaccine-type virus from OPVs is allowed to circulate continuously in an under-vaccinated population and regain its infectious abilities.

### Agent

Poliovirus is an RNA enterovirus from the Picornaviridae family. There are three serotypes, but immunity to one serotype does not produce significant immunity to another.

The virus is rapidly inactivated by heat (>50°C/122°F), formaldehyde, chlorine, and ultraviolet light, but is stable at an acidic pH and resistant to common alcohol-based sanitizers. A 0.5% dilution of chlorine bleach is the recommended surface disinfectant.

### Transmission

Reservoir:

Humans.

**Mode of transmission:**

- Polio is transmitted by the fecal-oral or oral-oral routes. The virus enters through the mouth and multiplies in the oropharynx and gastrointestinal tract.

**Period of communicability:**

- Polio is highly infectious, with seroconversion rates near 100% among susceptible household contacts of pediatric cases, and >90% among susceptible household contacts of adult cases. The virus is usually present in nasopharyngeal secretions for 1 to 2 weeks and can be shed in stool for several weeks after infection, even in people with mild or no symptoms. Cases are most infectious in the days immediately before and after the onset of symptoms (although the earliest possible date a case is infectious is not clearly defined).

### Clinical Disease

**Incubation period:**

- Nonparalytic poliomyelitis: 3 to 6 days
- Paralytic poliomyelitis: Usually 7 to 21 days to onset of paralysis. (Range 3-35 days)

**Illness:**

- ~70% of infections in children are asymptomatic.
- ~24% of children with poliovirus experience mild, non-specific symptoms such as low-grade fever and sore throat, and will recover within a week.
- ~1-5% of children with poliovirus develop nonparalytic aseptic meningitis, presenting with stiffness of the neck, back, or legs, usually lasting 2-10 days and followed by complete recovery. Increased or abnormal sensation (e.g., pain in the neck, back, or limbs), headache, and vomiting can also occur. These symptoms usually occur after a prodrome of several days of minor illness.
- <1% of children with poliovirus develop flaccid paralysis, progressing over the course of 2-3 days.
  - Paralysis is often permanent
  - Case fatality of paralytic polio is approximately 2-5% in children and up to 15-30% in adolescents and adults
    - Case fatality increases to 25-75% with bulbar involvement (see below)

**Paralytic Polio**

Paralysis occurs when the virus moves from the intestinal tract to the bloodstream and then to the central nervous system, where it destroys the motor neurons of the anterior horn of the spinal cord and cells of the brainstem. Paralysis tends to be asymmetrical, more severe proximally (e.g., in the muscles closer to the trunk of the body), with reduced or absent deep tendon reflexes but intact sensation. Children may experience a minor illness lasting several days and an apparent recovery lasting 2-3 days, before a second phase of fever, muscle pain, and paralysis. Adolescents and adults tend to skip the initial minor illness but experience more severe pain and paralysis.

There are three types of paralytic polio:

- Spinal polio: most common; asymmetric paralysis most often involving the legs
- Bulbar polio: least common and most deadly; involves weakness of facial, oropharyngeal, and respiratory muscles associated with cranial nerves
- Bulbospinal polio: combination of bulbar and spinal paralysis

Approximately 15-40 years after paralytic polio in childhood, 25-40% of survivors experience post-polio syndrome. This is a recurrence of muscle pain and exacerbation of existing weakness, or even the development of new weakness or paralysis. However, people with post-polio syndrome are not infectious with poliovirus.

## Vaccine-Associated and Vaccine-Derived Polio

Two of the three serotypes of wild poliovirus have been eradicated thanks to widespread vaccination, and the third type remains endemic only in under-vaccinated pockets of Pakistan and Afghanistan. However, exposure to wild-type poliovirus is not the only risk factor for polio.

There are two basic types of polio vaccines available today: inactivated (or injected) polio vaccine (IPV) and oral polio vaccine (OPV), which uses a live attenuated virus. Both vaccines confer humoral immunity (antibodies in the blood), making them highly effective at preventing paralytic polio. IPV does not contain any live virus; a drawback is that this vaccine does not effectively prevent replication of the virus in the gut, meaning an IPV-vaccinated person could still transmit virus via stool if they were exposed. (IPV is currently the only type available in the United States.) In contrast, OPV does confer immunity in the gut, which is crucial to interrupting transmission in areas where polio has not yet been eradicated. OPV is also relatively cheap and easy to administer. However, there is a rare risk of developing polio from OPV in two ways:

1. Vaccine-Associated Paralytic Poliovirus (VAPP), in which the vaccine recipient or their close contact develops polio directly from the virus contained in the vaccine, if their immune system was not able to neutralize the weakened virus. This extremely rare complication, occurring approximately 3.8 times per million doses of OPV, has been associated with (sometimes unrecognized) patient immunodeficiency, and may also be affected by the timing of the first OPV dose and circulating maternal antibodies. To reduce the risk of VAPP, countries transitioning from OPV to IPV are recommended to start the vaccine series with IPV, and use OPV for the later doses.
2. Vaccine-Derived Poliomyelitis can occur when the vaccine virus shed by an OPV recipient is allowed to proliferate unchecked in an under-vaccinated community (often facilitated by poor sanitation), giving the virus the opportunity to mutate and revert back to virulence. Somewhat paradoxically, combating vaccine-derived polio requires *more* vaccination, to increase herd immunity and therefore stop the vaccine virus from being able to spread too far.

## Laboratory Diagnosis

Polio infection must be confirmed by viral culture, preferably from a stool specimen (to be tested at CDC). Viral shedding is intermittent and declines after paralysis onset; therefore, CDC recommends collecting two stool specimens 24 hours apart, as early as possible within 14 days after the onset of symptoms. If the viral culture is positive, testing proceeds to RT-PCR and genomic sequencing to determine the serotype (1, 2, or 3) and whether the virus is a wild-type, vaccine type, or vaccine-derived strain.

Poliovirus is less likely to be recovered from the pharynx (with best results during the first 3-10 days after paralysis onset) and is rarely recovered from cerebrospinal fluid (CSF) or blood. However, blood, CSF, and a throat swab or nasopharyngeal swab should still be collected in addition to stool, to evaluate for other possible diagnoses if polio is ruled out. (See chapter on Acute Flaccid Myelitis for more information.)

Serology for all three types of poliovirus is no longer available commercially due to regulations for poliovirus containment.



## Treatment

Supportive. Physical and/or occupational therapy can improve arm or leg weakness, especially if begun early in the course of illness; however, the paralysis is generally permanent. Mechanical ventilation may also be required when paralysis affects the respiratory muscles.

## Surveillance

**Note:** Due to conflicts with the case definition for Acute Flaccid Myelitis, and changes in diagnostic testing and global epidemiology of polio occurring since the 2010 case definition was approved, the Council of State and Territorial Epidemiologists (CSTE) voted to significantly revise the case definitions for polio at the 2023 Conference, taking effect in January 2024.

### Case Definition (2024)

Clinical Criteria: Acute onset of flaccid paralysis with decreased or absent tendon reflexes in the affected limbs, in the absence of a more likely alternative diagnosis.

### Confirmatory Laboratory Evidence:

- Poliovirus detected by sequencing of the capsid region of the genome by the CDC Poliovirus Laboratory, **OR**
- Poliovirus detected in an appropriate clinical specimen (e.g., stool [preferred], cerebrospinal fluid, oropharyngeal secretions) using a properly validated assay<sup>^</sup>, **AND** specimen is not available for sequencing by the CDC Poliovirus Laboratory.

<sup>^</sup> *The Global Polio Laboratory Network (GPLN) provides guidelines on acceptance of results from labs that are not in GLPN; assays would have to be validated and approved by GPLN. CDC is part of GPLN.*

### Confirmed:

Paralytic Poliomyelitis: Meets clinical criteria **and** confirmatory laboratory evidence.

Nonparalytic Poliovirus Infection: Meets confirmatory laboratory evidence.

There is no Probable case definition.

### Reporting:

Report all suspected cases to the Epidemiology and Response Division (ERD) at 505-827-0006. Information needed includes: patient's name, age, sex, race, ethnicity, home address, home phone number, health care provider, travel history, and vaccination history if available.

Paralytic polio is classified as "Immediately Notifiable, Extremely Urgent" by CDC, which requires that local and state health departments contact CDC about suspected cases within 4 hours (Emergency Operations Center, 770-488-7100).

### Case Investigation:

Complete the [Suspected Polio Case Worksheet](#) and mail to the Epidemiology and Response Division, P.O. Box 26110, Santa Fe, New Mexico 87502-6110, or (preferably) fax to 505-827-0013. Investigation information should also be entered in NMEDSS per established procedures.

Note that polio and acute flaccid myelitis cases are clinically indistinguishable, so unless there is a particularly strong suspicion for polio due to known exposures or travel history, investigators should first complete an investigation for Acute Flaccid Myelitis until polio is definitively diagnosed by testing at CDC. (See AFM chapter for more details).

### **Control Measures**

**Note:** All suspected cases of polio should immediately be reported to CDC; the following guidance is preliminary and may be superseded or supplemented by situation-specific guidance provided by experts at CDC.

1. Case management
  - 1.1. Isolation: In addition to standard precautions, the American Academy of Pediatrics recommends contact precautions in infants and young children for the duration of hospitalization.
  - 1.2. The case should have their own private bathroom, and be restricted from food preparation, childcare, sexual contact, and shared toilets for the duration of the infectious period.
2. Contact management
  - 2.1. Identify close contacts who were exposed to the case during their infectious period. (Use the day of illness onset as day zero and consult CDC for further instructions on timing.) Close contacts include the following, regardless of vaccination status:
    - All household contacts
    - Sexual contacts
    - Caretakers
    - Anyone who shared toilet facilities with the case
    - Anyone who consumed food prepared by the case
    - First responders or healthcare workers who cared for the case without using PPE
  - 2.2. Due to the high likelihood of undetected subclinical or asymptomatic polio infections around a single paralytic polio case, testing of household contacts and other close contacts will likely be advised; consult with CDC for situation-specific guidance.
  - 2.3. Unvaccinated or under-vaccinated contacts will be at higher risk for disease; however, because IPV does not prevent gastrointestinal shedding of poliovirus, and mucosal immunity from OPV wanes over time, close contacts will need to be evaluated regardless of their vaccination status.
3. Prevention
  - 3.1. Only IPV is currently available in the United States. People born in the United States before 2000, or in other countries, may have received one or more doses of OPV. After

May 16, 2016, there was a global switch from trivalent OPV to bivalent OPV (covering only serotypes 1 and 3). Bivalent OPV (bOPV) is used primarily in low- or middle-income countries, with a goal of eventually transitioning to IPV.

- 3.2. IPV results in seroconversion to each of the three serotypes in 95% of two-dose recipients, and 99-100% of recipients after three doses, with likely lifelong immunity.
  - A four-dose schedule of IPV is used in the United States. The doses should be given at 2 months, 4 months, and 6-18 months of age, with a final dose at 4 years or older (and at least 6 months after the third dose).
    - It's possible that IPV may be given in combination with other vaccines at 2, 4, 6, and 12-15 months of age; in this situation, a fifth and final dose should be given at age 4 years or older, with a minimum interval of 6 months after the fourth dose.
  - For more information on the recommended schedule, see the ACIP immunization schedule here: <https://www.cdc.gov/vaccines/schedules/hcp/imz/child-adolescent.html>.
  - Most adults in the United States received polio vaccine during childhood. However, if an adult has no evidence of immunity and is traveling to an area where poliovirus is spreading, they should receive two doses of IPV (given 4-8 weeks apart), with a third dose given 6-12 months after the second dose.
    - If there is not enough time to finish three doses before traveling, the person may shorten the interval between doses to 4 weeks (e.g., doses given at week 0, week 4, and week 8).
  - If an adult has previously completed a partial series of IPV or OPV, they should finish the remaining dose(s) using IPV before travel, with a 4-week interval between doses.
  - If an adult has previously completed a series of IPV or OPV, but will be traveling to a location with an increased risk of exposure to polio, one lifetime booster of IPV is recommended before travel.
- 3.3. Visit <https://polioeradication.org/polio-today/polio-now/public-health-emergency-status/> to see where polio has been detected recently.
- 3.4. IPV can be administered to people who are pregnant, breastfeeding, or immunocompromised, and can be given at the same time as other vaccines.

## Managing Polio in Childcare Centers

All staff and children should be up to date for their age on polio vaccination. In the event of a confirmed polio case in a childcare center, CDC will provide situation-specific guidance on contact tracing, cleaning, and testing.

## References

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See Polio Fact Sheets (English) (Spanish).