Polio and *Haemophilus influenzae* type b

Pink Book Webinar Series

Andrew Kroger MD, MPH
Medical Officer
Communications and Education Branch
ACIP Recommendations: Polio and Polio Vaccines
Poliomyelitis Disease

- First outbreak described in the U.S. in 1843

- Polio epidemics were reported each summer and fall

- More than 21,000 paralytic cases reported in the U.S. in 1952
Poliovirus

- Three serotypes of wild poliovirus:
  - WPV1
  - WPV2
  - WPV3

- Minimal heterotypic immunity between serotypes

- Rapidly inactivated by heat, chlorine, formaldehyde, and ultraviolet light
Poliomyelitis Pathogenesis

- Enters into mouth
- Replicates in pharynx and GI tract
- Hematologic spread to lymphatics and central nervous system
- Viral spread along nerve fibers
- Destruction of motor neurons

Racaniello VR. One hundred years of poliovirus pathogenesis. *Virology* 2006;344:9-16
Outcomes of Poliovirus Infection

- Asymptomatic
- Minor non-specific illness
- Aseptic meningitis
- Flaccid paralysis
Asymmetric paralysis
# Poliovirus Epidemiology

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Human</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission</td>
<td>Fecal-oral</td>
</tr>
<tr>
<td></td>
<td>Oral-oral possible</td>
</tr>
<tr>
<td>Communicability</td>
<td>Most infectious: 7–10 days before onset</td>
</tr>
<tr>
<td></td>
<td>Virus present in stool 3–6 weeks</td>
</tr>
</tbody>
</table>
Poliomyelitis—United States, 1980–2010

Vaccine–associated paralytic polio = VAPP

VAPP
Imported

Cases

Poliovirus Vaccines

- 1955–Inactivated vaccine
- 1963–Live, attenuated vaccine (OPV)
- 1987–Enhanced-potency, inactivated vaccine (IPV)
Enhanced Inactivated Polio Vaccine

- Highly effective in producing immunity to poliovirus
  - $\geq 90\%$ of recipients immune after 2 doses
  - $\geq 99\%$ of recipients immune after 3 doses

- Duration of immunity not known with certainty
## Polio-Containing Vaccine Products

<table>
<thead>
<tr>
<th>Product Abbreviation</th>
<th>Age Indications</th>
<th>IPV Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPOL (IPV)</td>
<td>6 weeks and older</td>
<td>Any dose in the series</td>
</tr>
<tr>
<td>Pediarix (DTaP-IPV-HepB)</td>
<td>6 weeks through 6 years</td>
<td>Doses 1 through 3</td>
</tr>
<tr>
<td>Pentacel (DTaP-IPV/Hib)</td>
<td>6 weeks through 4 years</td>
<td>Doses 1 through 4</td>
</tr>
<tr>
<td>Kinrix (DTaP-IPV)</td>
<td>4 through 6 years</td>
<td>Dose 4</td>
</tr>
<tr>
<td>Quadracel (DTaP-IPV)</td>
<td>4 through 6 years</td>
<td>Dose 4 or 5</td>
</tr>
</tbody>
</table>
## ACIP Polio Immunization Recommendations

### Routine Childhood Schedule

<table>
<thead>
<tr>
<th>IPV Dose</th>
<th>Routinely Recommended Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2 months</td>
</tr>
<tr>
<td>2</td>
<td>4 months</td>
</tr>
<tr>
<td>3</td>
<td>6–18 months</td>
</tr>
<tr>
<td>4</td>
<td>4–6 years</td>
</tr>
</tbody>
</table>
ACIP Polio Immunization Recommendations
Catch-Up Schedule

- Infants 6 months of age and younger, follow the recommended schedule intervals.
- If accelerated protection is needed (e.g., travel to polio-endemic area), minimum age and intervals may be followed.

<table>
<thead>
<tr>
<th>Dose</th>
<th>Minimum Age</th>
<th>Minimum Interval to the Next Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose 1</td>
<td>6 weeks</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Dose 2</td>
<td>10 weeks</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Dose 3</td>
<td>14 weeks</td>
<td>6 months</td>
</tr>
<tr>
<td>Dose 4</td>
<td>4 years</td>
<td>---------</td>
</tr>
</tbody>
</table>
ACIP Polio Immunization Recommendations
4th Dose and the Catch-Up Schedule

- A 4th dose is not necessary if the 3rd dose was administered:
  - At age 4 years or older AND
  - At least 6 months after the previous dose

- Children who have received 4 doses (or more) before 4 years of age need an additional dose
  - There should be at least 6 months between last and next-to-last dose
Mixed-product series containing both OPV and IPV is acceptable
   – Only trivalent OPV (tOPV) counts toward completing the series

Children with an incomplete series:
   – Administer IPV to complete a series that includes doses of OPV
   – Ensure doses met minimum ages and intervals

Administer 1 dose of IPV to children who received 4 doses of OPV (or more) before 4 years of age
   – There should be at least 6 months the last dose of OPV and the IPV dose
OPV Administered Outside the U.S.

- Use the date of administration to make a presumptive determination of what type of OPV was received
- Trivalent OPV was used throughout the world prior to April 2016
- Persons 18 years of age and younger with doses of OPV that do not count towards the U.S. vaccination requirements should receive IPV
ACIP Polio Immunization Recommendations

Adolescents and Adults

- Routine vaccination of U.S. residents 18 years of age or older is not necessary or recommended

- May consider vaccination of travelers to polio-endemic countries and selected lab workers
### ACIP Polio Immunization Recommendations

**Unvaccinated Adults**

- Use routine IPV schedule if possible
  - 0, 1–2 months, 6–12 months intervals

- If accelerated protection is needed (e.g., travel to polio-endemic area), use the minimum intervals

<table>
<thead>
<tr>
<th>Dose</th>
<th>Minimum Intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dose 1</td>
<td>4 weeks</td>
</tr>
<tr>
<td>Dose 2</td>
<td>6 months</td>
</tr>
<tr>
<td>Dose 3</td>
<td>-----------------</td>
</tr>
</tbody>
</table>
ACIP Polio Immunization Recommendations
Previously Vaccinated Adults

- **Previously completed series**
  - Administer 1 dose of IPV to those at risk

- **Incomplete series**
  - Administer remaining doses in series based on immunization history
  - No need to restart a valid, documented series
    - Valid = minimum intervals met
Contraindications and Precautions

- **Contraindication**
  - Severe allergic reaction to a vaccine component or following a prior dose of vaccine

- **Precaution**
  - Moderate to severe acute illness
IPV Adverse Reactions

- Local reactions: 2.8% (pain, redness, swelling)
- Severe reactions: rare
Polio Eradication

- Last case in the United States in 1979
- Western Hemisphere certified polio-free in 1994
- Last isolate of WPV2 was in India in October 1999
- Global eradication goal
Global Polio Eradication Initiative

SURVEILLANCE
- ADEQUATE STOOL COLLECTION (Rolling 12 Month Period)
- NONPOLIO ACUTE FLACCID PARALYSIS (Rolling 12 Month Period)
- ENVIRONMENTAL (Rolling 6 Month Period)

YEAR-TO-DATE 2019
Jan 1 - Aug 17, 2019
65 WPV 51 cVDPV

YEAR-TO-DATE 2018
Jan 1 - Aug 17, 2018
17 WPV 53 cVDPV
Clinical Considerations for IPV-Containing Vaccines

- **Storage:** Refrigerate between 2°C and 8°C (36°F and 46°F)
- **Preparation:** Prepare the vaccine just prior to administration
  - Pentacel requires reconstitution
  - Reconstitute the lyophilized vaccine with the DTaP-IPV liquid diluent supplied by the manufacturer. Do NOT use Kinrix or Quadracel
- **Route:** IM injection*
- **Site:**
  - 11 months and younger: Anterolateral thigh muscle
  - 12 months and older: Anterolateral thigh muscle or deltoid muscle of arm
- **Needle:**
  - Children: 22–25 gauge, 1-inch needle
  - Adults: 22–25 gauge, length varies by weight

*IPV may be administered by subcutaneous injection using a 5/8-inch needle given in the fatty tissue over the upper, outer triceps or anterolateral thigh
Polio: Vaccine Administration Errors

- **Schedule errors: Dose 4 administered too soon**
  - Doses administered 5 or more days before the minimum age and/or interval do not count and should be repeated when age-appropriate
  - Wait the minimum interval from the invalid dose before giving the repeat dose
  - Minimum age/interval: At/after age 4 AND 6 months after dose 3

- **Age/dose errors: Kinrix or Quadracel for doses 1 through 3**
  - If the minimum age and interval from the last dose of polio vaccine has been met, the dose can count and does not need to be repeated

- **Preparation errors: Wrong diluent to reconstitute DTaP-IPV/Hib (Pentacel)**
  - Do not use Kinrix or Quadracel to reconstitute Pentacel
ACIP Recommendations:

*Haemophilus influenzae* type b and Hib Vaccine
Haemophilus influenzae type b

- Severe bacterial infection, particularly among infants
- Aerobic gram-negative bacteria
- Polysaccharide capsule
- 6 different serotypes (a–f) of polysaccharide capsule
- 95% of invasive disease caused by type b (prevaccine era)
Impact of *Haemophilus influenzae* type b Disease

- Formerly the leading cause of bacterial meningitis among children younger than 5 years of age
- Approximately 1 in 200 children developed invasive Hib disease
- Almost all infections among children younger than 5 years
Haemophilus influenzae type b
Clinical Manifestations*

- Meningitis: 50%
- Epiglottitis: 17%
- Pneumonia: 15%
- Osteomyelitis: 2%
- Arthritis: 2%
- Cellulitis: 6%
- Bacteremia: 2%

*Prevaccine era
Facial cellulitis or infection of the soft tissues of the face, caused by Hib
**Haemophilus influenzae type b Epidemiology**

<table>
<thead>
<tr>
<th>Reservoir</th>
<th>Human asymptomatic carriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission</td>
<td>Respiratory droplets presumed</td>
</tr>
<tr>
<td>Temporal pattern</td>
<td>Peaks in Sept. through Dec. and March through May</td>
</tr>
<tr>
<td>Communicability</td>
<td>Generally limited but higher in some circumstances (e.g., household, child care)</td>
</tr>
</tbody>
</table>
Estimated Annual Incidence (per 100,000) of Invasive *Haemophilus influenzae* type b (Hib) Disease in Children Aged <5 Years—U.S., 1980–2012

First polysaccharide Hib vaccine licensed for use in children aged ≥18 months

First conjugate Hib vaccine licensed for use in children aged ≥18 months

First Hib vaccines licensed for use in infants aged ≥2 months

*MMWR* 2014;63(RR1):1–14
Haemophilus influenzae, Invasive Disease Incidence of Reported Cases (per 100,000), by serotype Among Children aged <5 years—U.S., 2000–2013

Healthy People 2020 Goal

0.27 per 100,000
Available 1985–1988
Not effective in children younger than 18 months of age
Efficacy in older children varied
Age-dependent immune response
Not consistently immunogenic in children 2 years of age and younger
No booster response
**Haemophilus influenzae Type b Conjugate Vaccines**

- Conjugation improves immunogenicity
  - Immune response with booster doses

- Same polysaccharide capsule linked to different carrier proteins

- 3 single-component conjugate Hib vaccine products

- 1 combination vaccine products available that contain Hib conjugate vaccine
## Hib-Containing Vaccine Products

<table>
<thead>
<tr>
<th>Vaccine product</th>
<th>Age indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRP-T (polysaccharide, tetanus toxoid)</td>
<td></td>
</tr>
<tr>
<td>ActHIB</td>
<td>All doses of primary schedule and booster dose 2 months through 5 years</td>
</tr>
<tr>
<td>Hiberix</td>
<td>All doses of primary schedule and booster dose 6 weeks through 4 years</td>
</tr>
<tr>
<td>Pentacel (DTaP, IPV, Hib)</td>
<td>For doses 1 through 4 6 weeks through 4 years of age</td>
</tr>
<tr>
<td>PRP-OMP (polysaccharide, outer membrane protein)</td>
<td></td>
</tr>
<tr>
<td>PedvaxHIB</td>
<td>All doses of primary schedule and booster dose 2 to 71 months of age</td>
</tr>
<tr>
<td>Vaxelis (DTaP, IPV, Hib, HepB)</td>
<td>All doses of primary schedule (2) and booster dose 6 weeks-4 years</td>
</tr>
</tbody>
</table>
ACIP Hib Immunization Recommendations

Routine Schedule

- Routinely recommended for all infants beginning at 2 months of age*

- Schedule varies based on the product used
  - ActHib, Pentacel, Hiberix: Follow the 4-dose schedule at 2, 4, 6, and 12–15 months of age
  - PedvaxHIB: Follow the 3-dose schedule at 2, 4, and 12–15 months of age

- If any dose in the series is ActHIB, Pentacel, Hiberix or the product is not known, follow the 4-dose schedule

*Minimum age for the 1st dose is 6 weeks
Children starting late may not need entire 3- or 4-dose series

Number of doses child requires depends on current age

Resources:
- 2018 catch-up schedule
- Catch-up guidance for healthy children
- Detailed schedule p. 128 of Pink Book
ACIP Hib Immunization Recommendations
Older Children and Adults

- Generally not recommended for healthy persons older than 59 months of age
- Vaccinate high-risk older children and adolescents if incompletely or previously unvaccinated
  - Asplenia
  - Immunodeficiency
  - HIV infection
  - Receipt of chemotherapy or radiation therapy
## ACIP Hib Immunization Recommendations
### High-Risk Children and Adults

<table>
<thead>
<tr>
<th>High-Risk Children and Adults</th>
<th>Hib Vaccine Guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elective splenectomy</td>
<td>If unvaccinated: 1 dose prior to procedure</td>
</tr>
<tr>
<td>Asplenic patient</td>
<td>If unvaccinated: 1 dose</td>
</tr>
<tr>
<td>HIV-infected children</td>
<td>If unvaccinated: 1 dose</td>
</tr>
<tr>
<td>Hematopoietic cell transplant</td>
<td>3 doses (at least 4 weeks apart) beginning 6–12 months after transplant</td>
</tr>
<tr>
<td>HIV-infected adults</td>
<td>Hib vaccination is not recommended</td>
</tr>
</tbody>
</table>
“Unvaccinated” and High-Risk Catch-Up

- “Unvaccinated” means someone who meets both criteria:

  Less than the routine series through 14 months;

  AND

  No doses after 14 months of age
Special Populations

- **Children less than 24 months of age with invasive Hib disease**
  - Administer complete series as recommended for child’s age
  - Vaccinate during the convalescent phase of the illness

- **American Indian/Alaska natives**
  - Hib disease peaks earlier in infancy
  - PedVaxHIB vaccine produces protective antibody after first dose/early protection
  - PedVaxHIB vaccine is specifically recommended for primary series doses
Hib Vaccine Interchangeability

- All single-component conjugate Hib vaccines are interchangeable for primary series and booster dose

- 3-dose primary series (4 doses total) if more than one brand of vaccine used at 2 or 4 months of age

- Whenever feasible, use same combination vaccine for subsequent doses

- If vaccine used for earlier doses is not known or not available, any brand may be used to complete the series
Contraindications and Precautions

- Severe allergic reaction to vaccine component or following previous dose
- Moderate to severe acute illness
- Age younger than 6 weeks
Hib Vaccine Adverse Reactions

- Swelling, redness, or pain in 5–30% of recipients
- Systemic reactions infrequent
- Serious adverse reactions rare
Clinical Considerations for Hib-Containing Vaccine

- **Storage**: Refrigerate between 2°C and 8°C (36°F and 46°F)
- **Preparation**: Prepare vaccine just prior to administration
  - ActHIB, Pentacel, and Hiberix require reconstitution
  - Reconstitute the lyophilized vaccine with the diluent supplied by the manufacturer
- **Route**: IM injection
- **Site**:
  - 11 months and younger: Anterolateral thigh muscle
  - 12 months and older: Anterolateral thigh muscle or deltoid muscle of arm
- **Needle**: 22–25 gauge, 1-inch needle
Hib: Vaccine Administration Errors

- Preparation errors: Using the wrong diluent to reconstitute the lyophilized component

CDC vaccine storage label examples [https://www.cdc.gov/vaccines/hcp/admin/storage/guide/vaccine-storage-labels.pdf](https://www.cdc.gov/vaccines/hcp/admin/storage/guide/vaccine-storage-labels.pdf)
Additional Clinical Considerations

- Provide the polio and Hib vaccine information statement (VIS) when a combination vaccine is administered
  - There are no VISs specific for Kinrix, Pediarix, Pentacel, or Quadracel
- Other option: multiple vaccines VIS
  - May be used in place of the individual VISs for DTaP, Hib, hepatitis B, polio, and PCV13 when two or more of these vaccines are administered during the same visit
  - It may be used for infants through children receiving their routine 4- to 6-year vaccines

CDC vaccine information statements  www.cdc.gov/vaccines/hcp/vis/vis-statements/multi.html
Resources and references are available on the webinar webpage.

Polio and vaccine resources and references

- **Resources and references are available on the webinar webpage.**

---

**Polio and Haemophilus influenzae type b Vaccines Resources and References**

**2018 Pink Book Webinar Series**

**ACIP recommendations**

- Current ACIP [Haemophilus influenzae type b vaccine recommendations](https://www.cdc.gov/vaccines/acip/addendum-hib.html)
- Current ACIP [Poliomyelitis vaccines recommendations](https://www.cdc.gov/vaccines/acip/recom-poliomy.html)

**Manufacturer’s vaccine package inserts (PI)**

- [DTaP](https://files.cdc.gov/links/cdc/DTaP_VaccinationGuide.pdf)
- [IPV](https://files.cdc.gov/links/cdc/Pentacel_vaccine_guideline_2018.pdf)
- [IPV](https://files.cdc.gov/links/cdc/Pentacel_vaccine_guideline_2018.pdf)
- [Pentacel](https://files.cdc.gov/links/cdc/Pentacel_vaccine_guideline_2018.pdf)
- [Pentacel](https://files.cdc.gov/links/cdc/Pentacel_vaccine_guideline_2018.pdf)
- [Pentacel](https://files.cdc.gov/links/cdc/Pentacel_vaccine_guideline_2018.pdf)

**Schedule**

- 2018 Recommended immunization schedule for persons age 18 years and younger: [www.cdc.gov/vaccines/schedules/hcp/child-adolescent.html](www.cdc.gov/vaccines/schedules/hcp/child-adolescent.html)
- 2018 Recommended immunization schedule for adults 18 years and older: [www.cdc.gov/vaccines/schedules/hcp/adult.html](www.cdc.gov/vaccines/schedules/hcp/adult.html)

**Disease**

- CDC [Haemophilus influenzae type b disease webpage](https://www.cdc.gov/ncidod/diseases/hib/index.html)
- CDC Polio disease webpage: [https://www.cdc.gov/polio/sap.htm](https://www.cdc.gov/polio/sap.htm)
- Polio epidemic information you need to know: [www.cdc.gov/vaccines/pubs/pocketbook-polio.pdf](www.cdc.gov/vaccines/pubs/pocketbook-polio.pdf)

**Information for health care personnel**

- Epidemiology and Prevention of Vaccine-Preventable Disease: Haemophilus influenzae type b chapter: [www.cdc.gov/vaccines/pubs/pocketbook-polio.pdf](www.cdc.gov/vaccines/pubs/pocketbook-polio.pdf)
- Epidemiology and Prevention of Vaccine-Preventable Diseases: Polio [guide](www.cdc.gov/vaccines/pubs/pocketbook-polio.pdf)