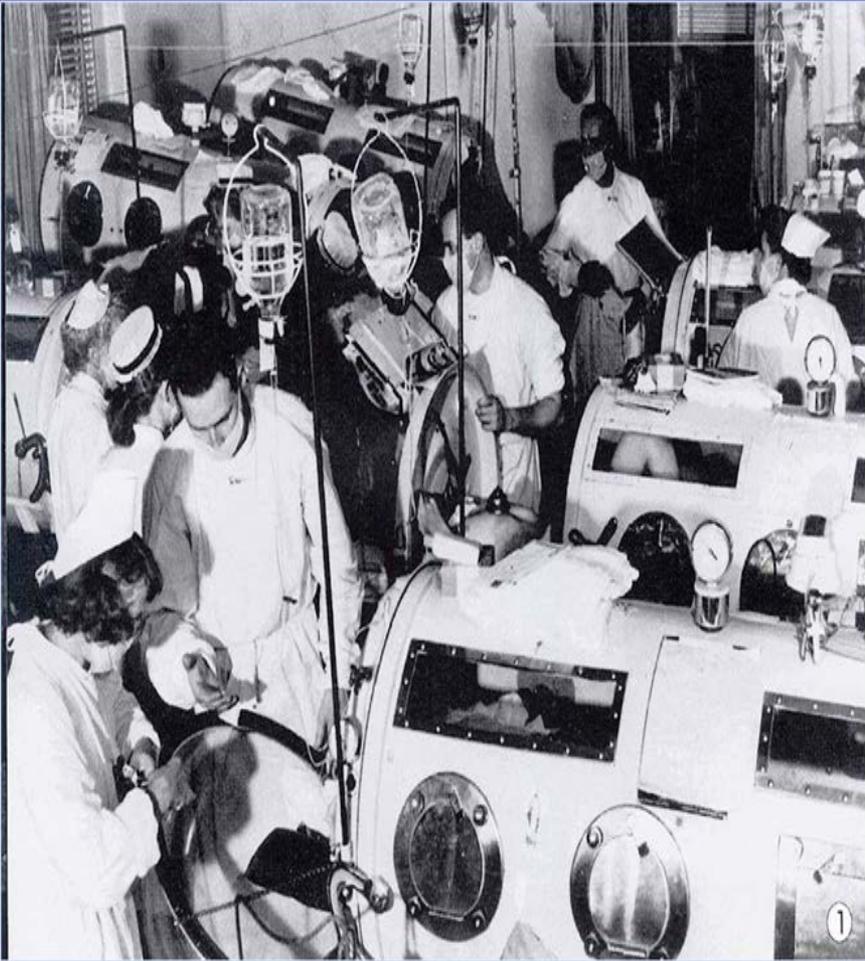


# Polio and Polio Vaccine

**Candice Robinson, MD, MPH**  
**Medical Officer**  
**Communication and Education Branch**

# Poliomyelitis Disease



- ❑ First outbreak described in the U.S. in 1843
- ❑ More than 21,000 paralytic cases reported in the U.S. in 1952
- ❑ Global eradication within this decade

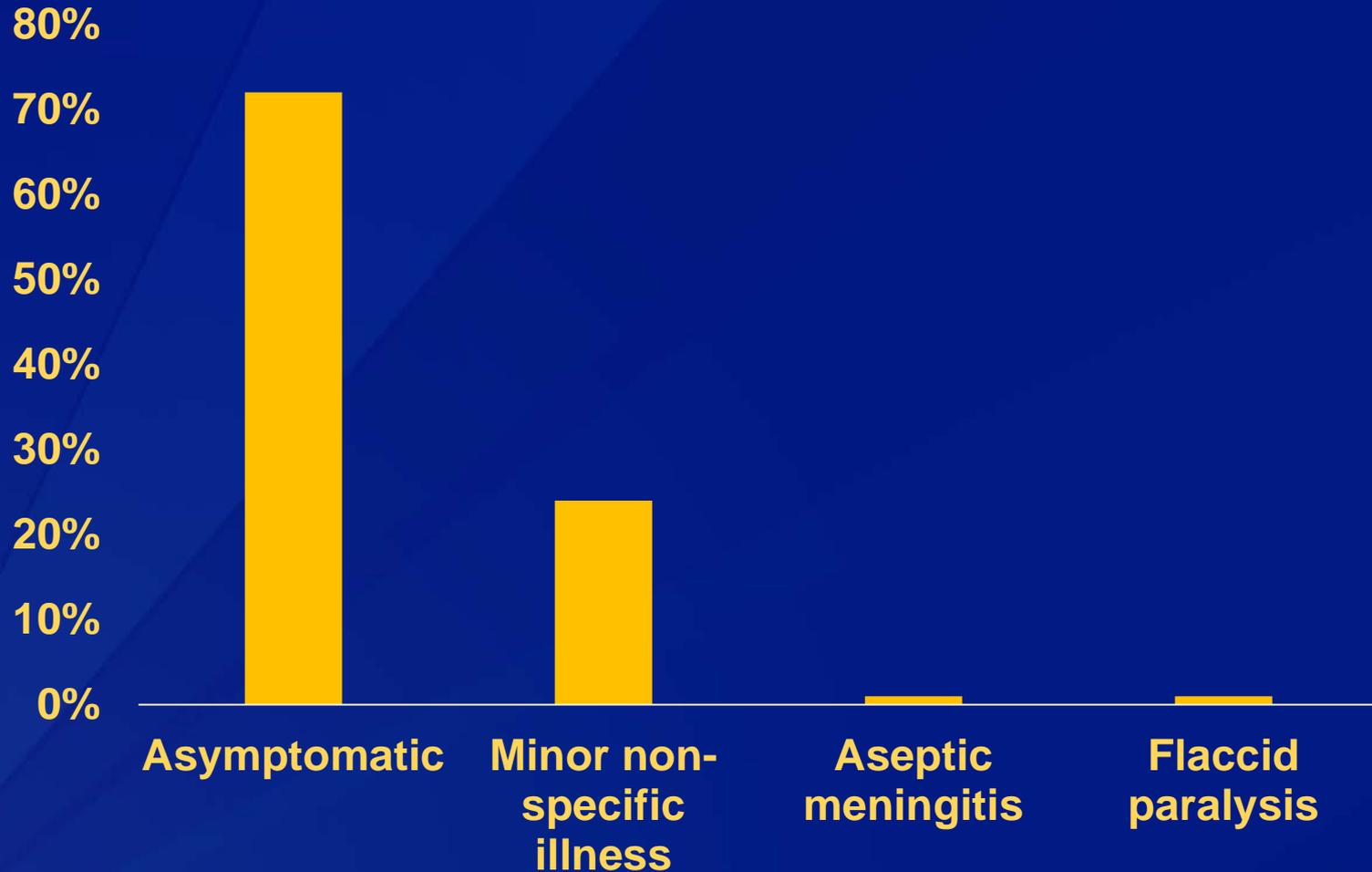
# Poliovirus

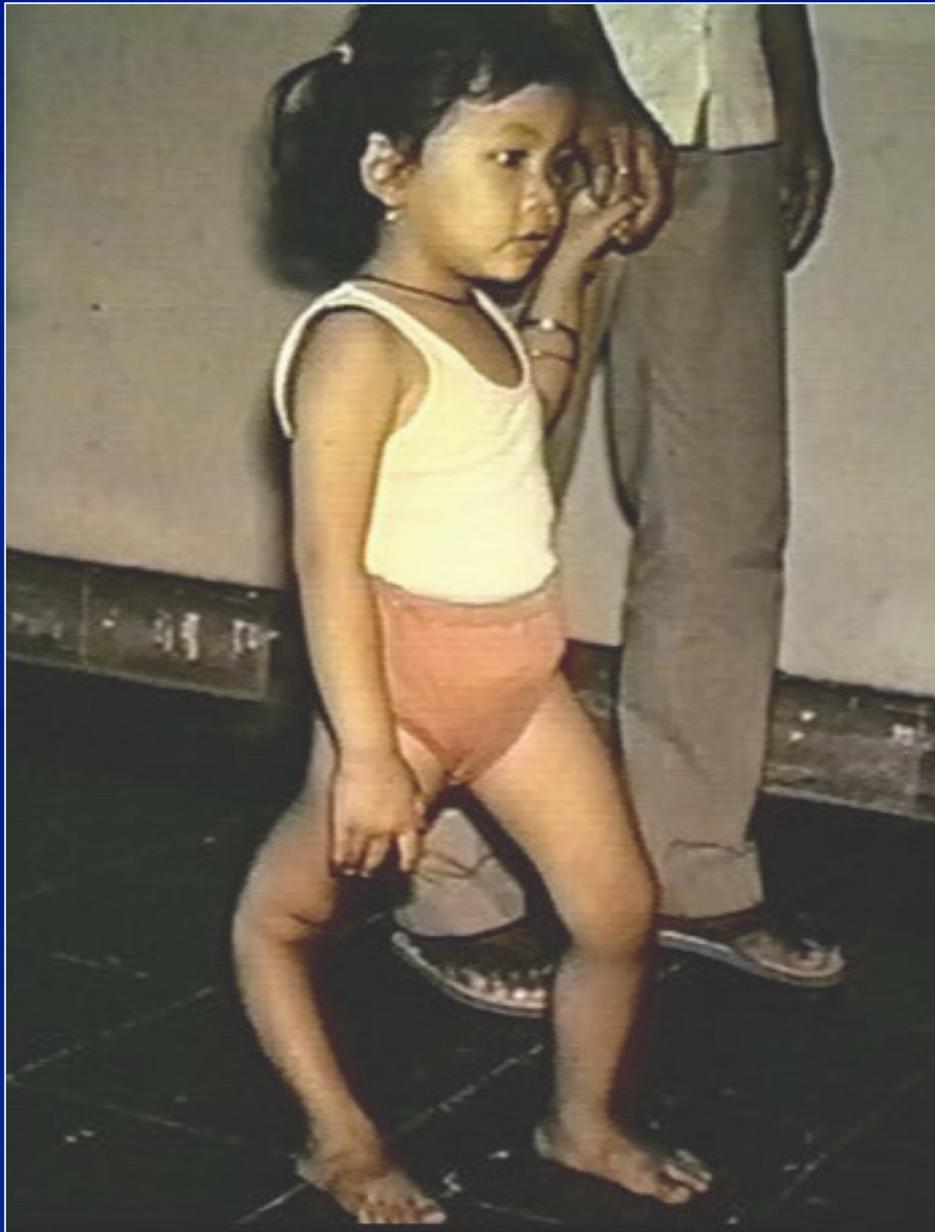
- ❑ Three serotypes: 1, 2, 3
- ❑ Minimal heterotypic immunity between serotypes
- ❑ Rapidly inactivated by heat, chlorine, formaldehyde, and ultraviolet light

# Poliomyelitis Pathogenesis

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

# Outcomes of Poliovirus Infection

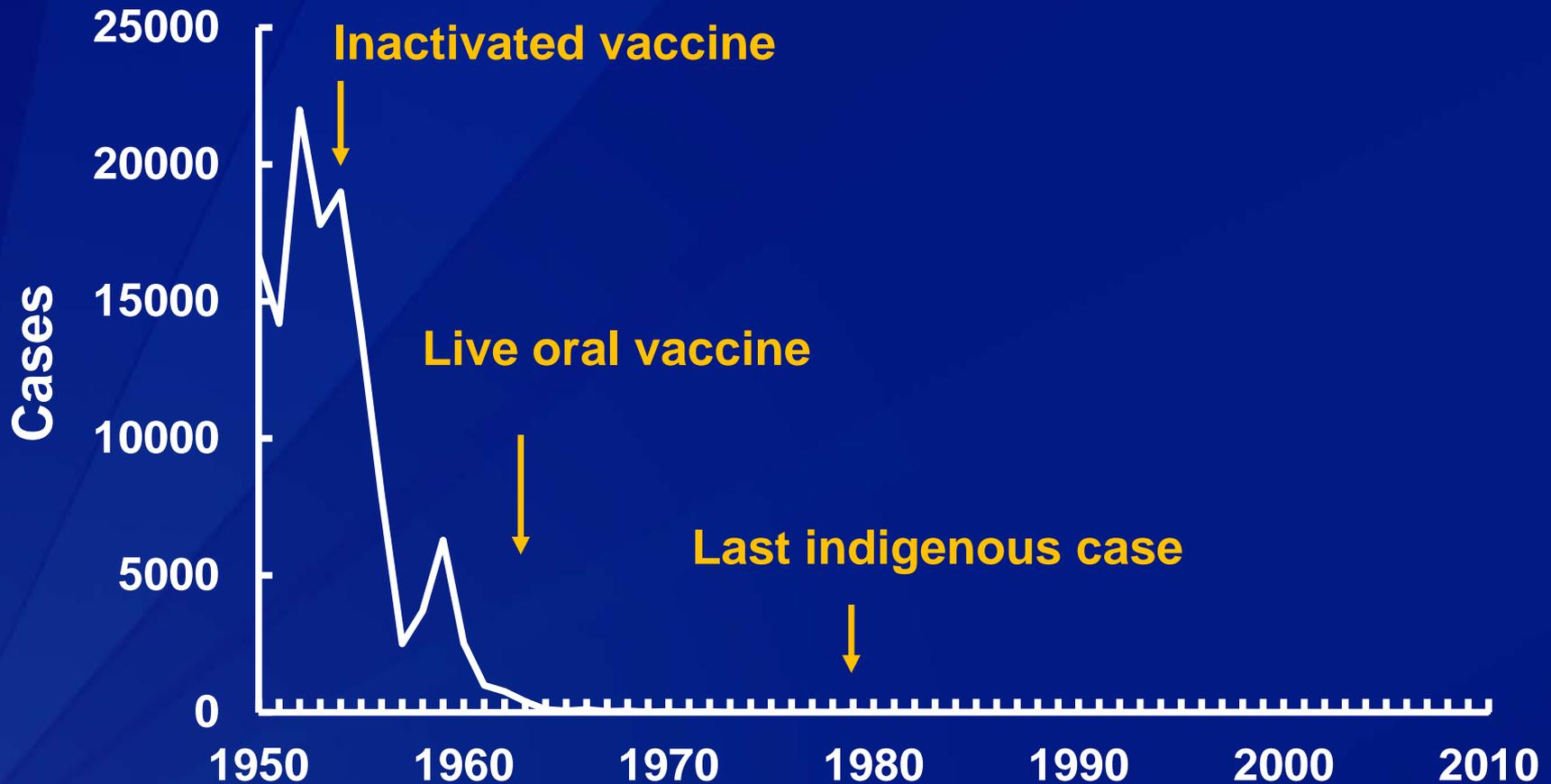




# Poliovirus Epidemiology

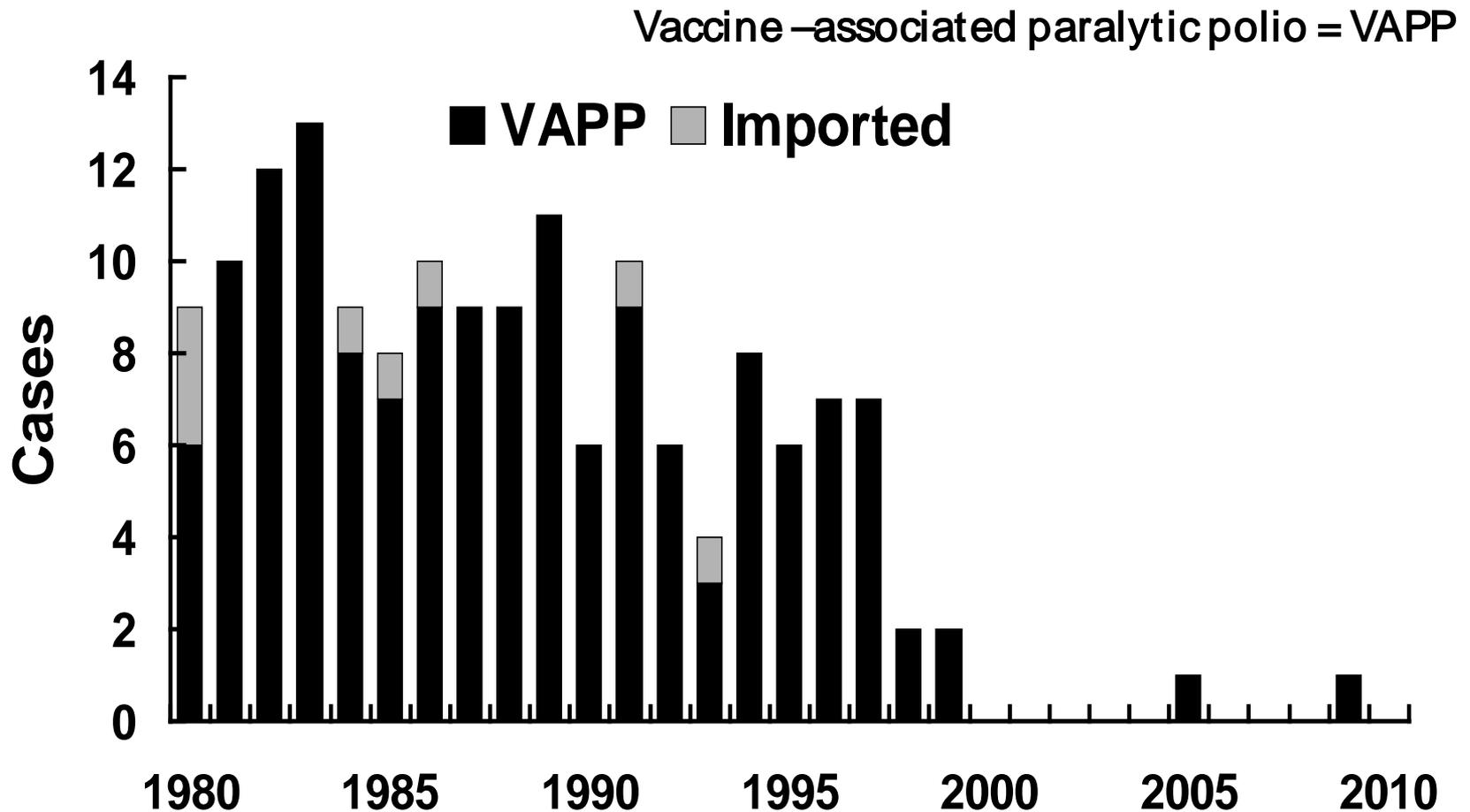
- ❑ **Reservoir** Human
- ❑ **Transmission** Fecal-oral  
Oral-oral possible
- ❑ **Communicability** Most infectious: 7-10 days before onset  
Virus present in stool 3-6 weeks

# Poliomyelitis—United States, 1950-2011



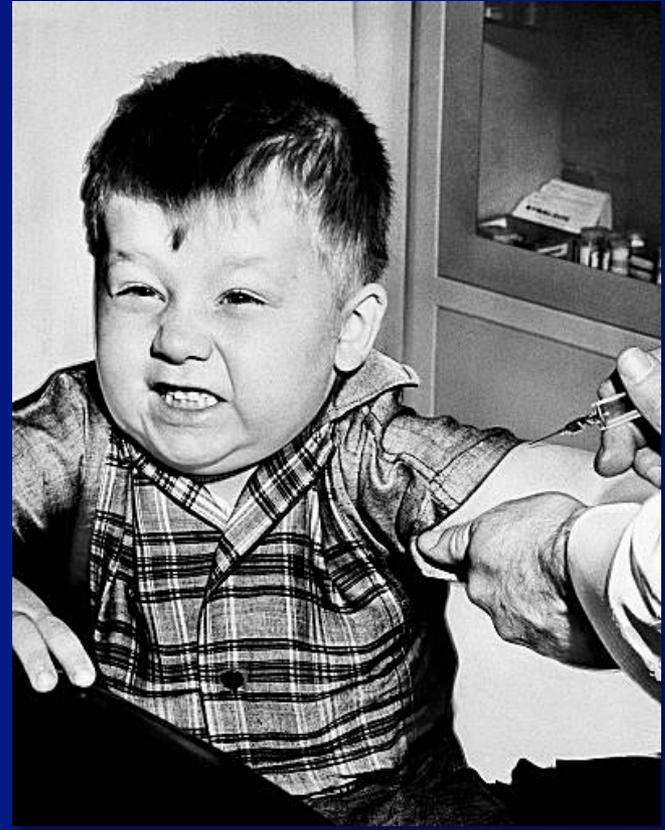
Source: National Notifiable Disease Surveillance System, CDC

# Poliomyelitis—United States, 1980-2010



# Poliovirus Vaccines

- ❑ 1955 - Inactivated vaccine
- ❑ 1963 - Trivalent OPV
- ❑ 1987 – Enhanced-potency (IPV)



# 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**

**Figure 1. Recommended immunization schedule for persons aged 0 through 18 years – United States, 2015.**

**(FOR THOSE WHO FALL BEHIND OR START LATE, SEE THE CATCH-UP SCHEDULE [FIGURE 2]).**

These recommendations must be read with the footnotes that follow. For those who fall behind or start late, provide catch-up vaccination at the earliest opportunity as indicated by the green bars in Figure 1. To determine minimum intervals between doses, see the catch-up schedule (Figure 2). School entry and adolescent vaccine age groups are shaded.

Vaccine	Birth	1 mo	2 mos	4 mos	6 mos	9 mos	12 mos	15 mos	18 mos	19–23 mos	2–3 yrs	4–6 yrs	7–10 yrs	11–12 yrs	13–15 yrs	16–18 yrs	
Hepatitis B <sup>1</sup> (HepB)	1 <sup>st</sup> dose	← 2 <sup>nd</sup> dose →			← 3 <sup>rd</sup> dose →												
Rotavirus <sup>2</sup> (RV) RV1 (2-dose series); RV5 (3-dose series)			1 <sup>st</sup> dose	2 <sup>nd</sup> dose	See footnote 2												
Diphtheria, tetanus, & acellular pertussis <sup>3</sup> (DTaP: <7 yrs)			1 <sup>st</sup> dose	2 <sup>nd</sup> dose	3 <sup>rd</sup> dose				← 4 <sup>th</sup> dose →			5 <sup>th</sup> dose					
Tetanus, diphtheria, & acellular pertussis <sup>4</sup> (Tdap: ≥7 yrs)														(Tdap)			
Haemophilus influenzae type b <sup>5</sup> (Hib)			1 <sup>st</sup> dose	2 <sup>nd</sup> dose	See footnote 5				← 3 <sup>rd</sup> or 4 <sup>th</sup> dose → See footnote 5								
Pneumococcal conjugate <sup>6</sup> (PCV13)			1 <sup>st</sup> dose	2 <sup>nd</sup> dose	3 <sup>rd</sup> dose				← 4 <sup>th</sup> dose →								
Pneumococcal polysaccharide <sup>6</sup> (PPSV23)																	
Inactivated poliovirus <sup>7</sup> (IPV: <18 yrs)			1 <sup>st</sup> dose	2 <sup>nd</sup> dose	← 3 <sup>rd</sup> dose →							4 <sup>th</sup> dose					
Influenza <sup>8</sup> (IV; LAIV) 2 doses for some: See footnote 8					Annual vaccination (IV only) 1 or 2 doses						Annual vaccination (LAIV or IV) 1 or 2 doses		Annual vaccination (LAIV or IV) 1 dose only				
Measles, mumps, rubella <sup>9</sup> (MMR)					See footnote 9				← 1 <sup>st</sup> dose →			2 <sup>nd</sup> dose					
Varicella <sup>10</sup> (VAR)									← 1 <sup>st</sup> dose →			2 <sup>nd</sup> dose					
Hepatitis A <sup>11</sup> (HepA)									← 2-dose series, See footnote 11 →								
Human papillomavirus <sup>12</sup> (HPV2: females only; HPV4: males and females)															(3-dose series)		
Meningococcal <sup>13</sup> (Hib-MenCY ≥ 6 weeks; MenACWY-D ≥ 9 mos; MenACWY-CRM ≥ 2 mos)					See footnote 13										1 <sup>st</sup> dose		Booster

Range of recommended ages for all children
Range of recommended ages for catch-up immunization
Range of recommended ages for certain high-risk groups
Range of recommended ages during which catch-up is encouraged and for certain high-risk groups
Not routinely recommended

This schedule includes recommendations in effect as of January 1, 2015. Any dose not administered at the recommended age should be administered at a subsequent visit, when indicated and feasible. The use of a combination vaccine generally is preferred over separate injections of its equivalent component vaccines. Vaccination providers should consult the relevant Advisory Committee on Immunization Practices (ACIP) statement for detailed recommendations, available online at <http://www.cdc.gov/vaccines/hcp/acip-recs/index.html>. Clinically significant adverse events that follow vaccination should be reported to the Vaccine Adverse Event Reporting System (VAERS) online (<http://www.vaers.hhs.gov>) or by telephone (800-822-7967). Suspected cases of vaccine-preventable diseases should be reported to the state or local health department. Additional information, including precautions and contraindications for vaccination, is available from CDC online (<http://www.cdc.gov/vaccines/recs/vac-admin/contraindications.htm>) or by telephone (800-CDC-INFO [800-232-4636]).

This schedule is approved by the Advisory Committee on Immunization Practices (<http://www.cdc.gov/vaccines/acip>), the American Academy of Pediatrics (<http://www.aap.org>), the American Academy of Family Physicians (<http://www.aafp.org>), and the American College of Obstetricians and Gynecologists (<http://www.acog.org>).

**NOTE: The above recommendations must be read along with the footnotes of this schedule.**

# Childhood Polio Vaccination Schedule

Vaccine	Birth	1 mo	2 mos	4 mos	6 mos	9 mos	12 mos	15 mos	18 mos	19-23 mos	2-3 yrs	4-6 yrs	7-10 yrs	11-12 yrs	13-15 yrs	16-18 yrs
Inactivated poliovirus <sup>7</sup> (IPV) (<18 yrs)			1 <sup>st</sup> dose	2 <sup>nd</sup> dose	←----- 3 <sup>rd</sup> dose -----→						4 <sup>th</sup> dose					

**IPV  
Dose**

**Routinely  
Recommended at**

**Minimum  
Interval**

**1**

**2 months of age**

-----

**2**

**4 months of age**

**4 weeks**

**3**

**6- 18 months of age**

**4 weeks**

**4**

**4-5 years of age**

**6 months**

# Childhood IPV Recommendations

- ❑ A dose of IPV should be given on/after the 4<sup>th</sup> birthday
  - Even if 4 (or more) doses of IPV already received
- ❑ Minimum interval between the 4<sup>th</sup> and 5<sup>th</sup> doses is 6 months
- ❑ A 4<sup>th</sup> dose not required if 3<sup>rd</sup> dose given at 4 years of age or older
  - Vaccination history must be all IPV or all OPV only

# Schedules that Include Both IPV and OPV

- ❑ Only IPV is available in the United States
- ❑ Schedule begun with OPV should be completed with IPV
- ❑ Any combination of 4 doses of IPV and OPV with the final dose given at 4 years of age or older constitutes a complete series

# Poliovirus-containing Vaccine Products

- Single component vaccine - IPV
- **FOUR** polio-containing combination vaccine products:
  - DTaP-**IPV**/Hib (Pentacel)
  - DTaP-HepB-**IPV** (Pediarix)
  - DTaP-**IPV** (Kinrix)
  - DTaP-**IPV** (Quadracel)

# DTaP-IPV/Hib (Pentacel)

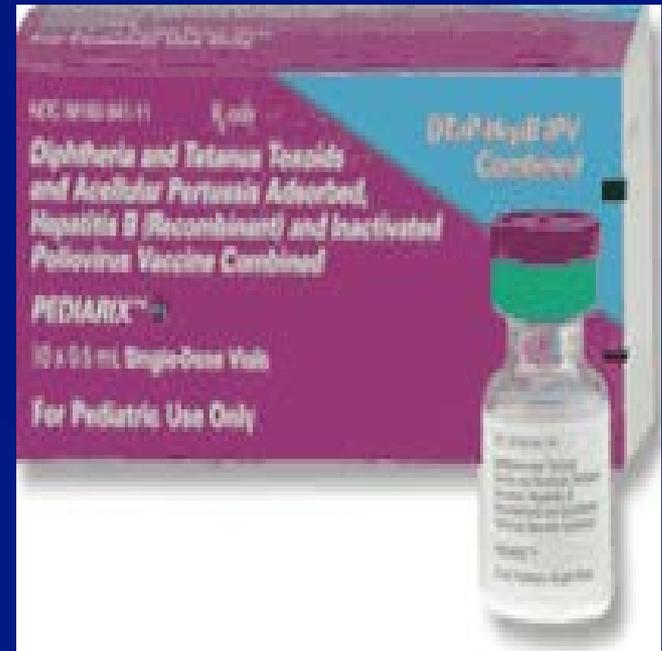
- FDA-approved for:
  - IPV doses 1 through 4
  - Children 6 weeks through 4 years of age
- Use DTaP-IPV diluent to reconstitute the Hib component



**Reminder: Only use the manufacturer's supplied diluent**

# DTaP-HepB-IPV (Pediatrix)

- FDA-approved for:
  - IPV doses 1 through 3
  - Children 6 weeks through 6 years of age



# DTaP-IPV (Kinrix & Quadracel)

## □ Kinrix

- IPV dose 4
- Children 4 through 6 years of age



## □ Quadracel

- IPV dose 4 or 5
- 4 through 6 years of age



VA error: Do NOT use to reconstitute the Hib component of Pentacel vaccine

# Polio Vaccination of 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

# Polio Vaccination of Unvaccinated Adults

- ❑ Use standard IPV schedule if possible
  - 0, 1-2 months, 6-12 months intervals
- ❑ May separate first and second doses by 4 weeks if accelerated schedule needed
- ❑ The minimum interval between the second and third doses is 6 months

# Polio Vaccination of 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

- ❑ Severe allergic reaction to a vaccine component or following a prior dose of vaccine
- ❑ Moderate to severe acute illness

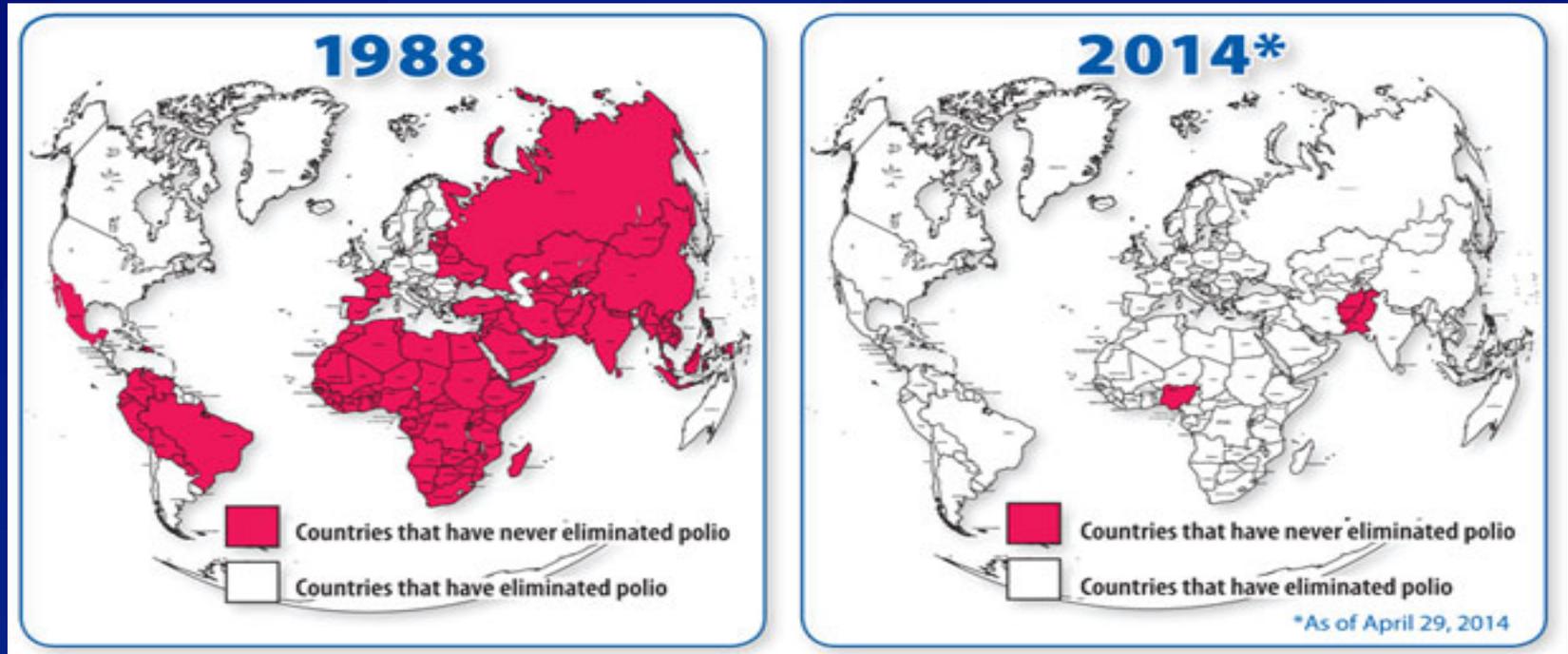
# IPV Adverse Reactions

- ❑ 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 type 2 polio virus in India in October 1999
- ❑ Global eradication goal

# Global Polio Efforts



- ❑ The number of worldwide reported cases have decreased from an estimated 350,000 in 1988
- ❑ Since August 2014 wild polio virus has been detected in just two countries: Afghanistan and Pakistan

# *Haemophilus influenzae* type b and Hib Vaccine

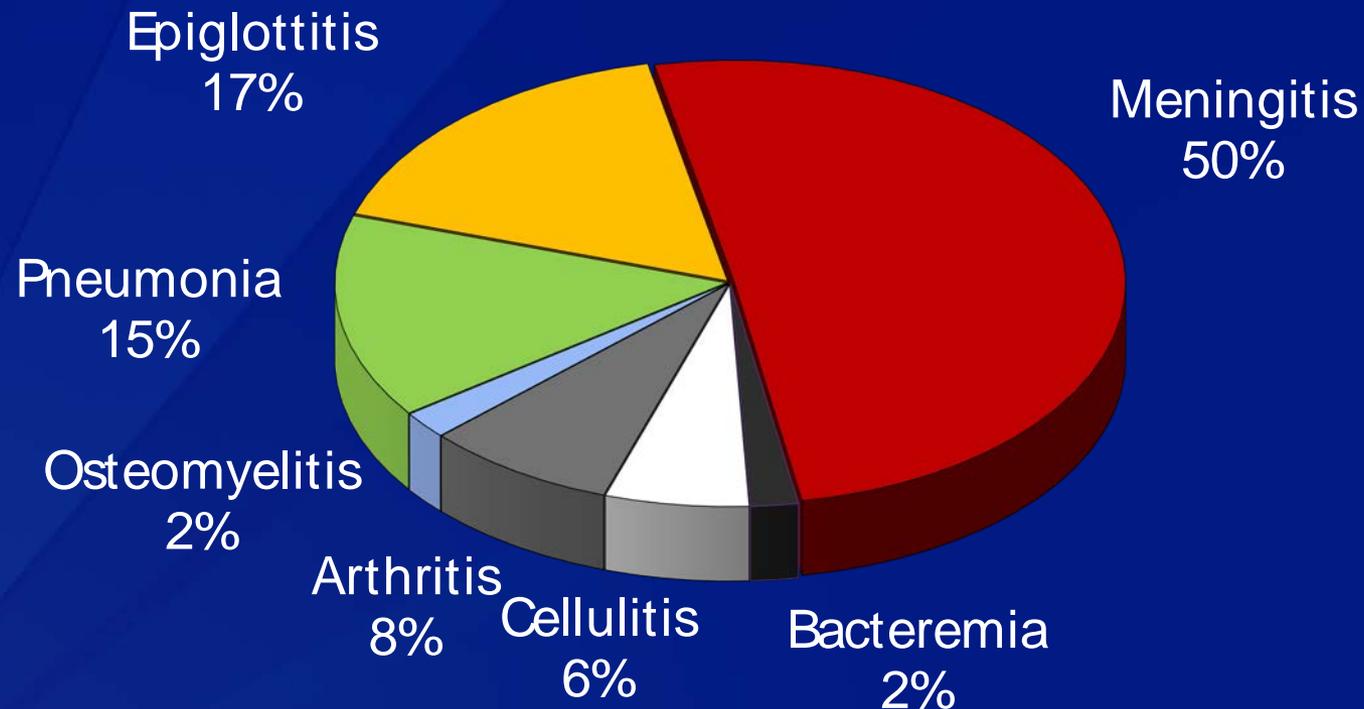
# *Haemophilus influenzae*

- ❑ 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\*



\*Prevaccine era



Hib facial cellulitis

# *Haemophilus influenzae* type b

## Epidemiology

❑ Reservoir

Human asymptomatic carriers

❑ Transmission

Respiratory droplets presumed

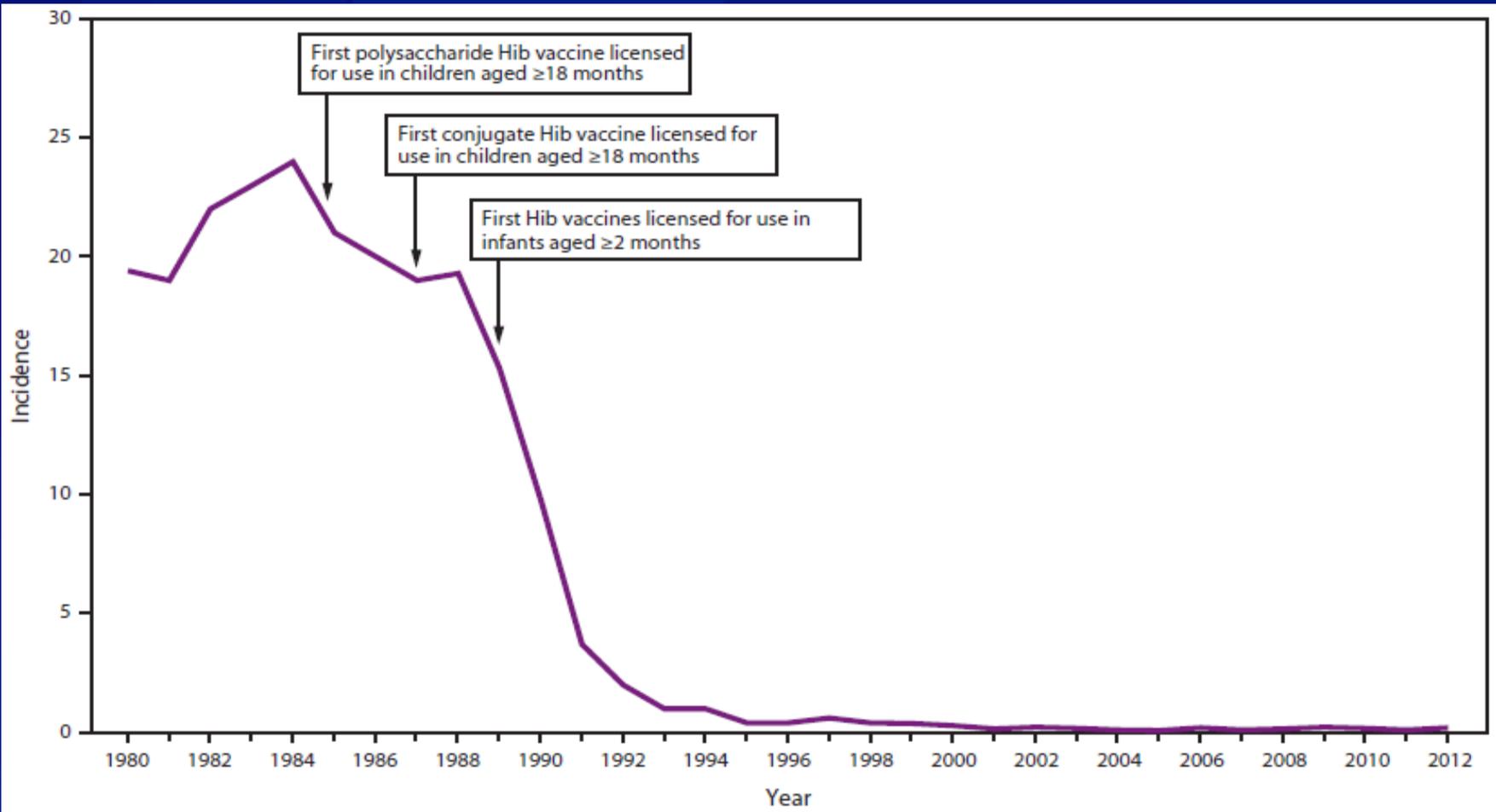
❑ Temporal pattern

Peaks in Sept-Dec and March-May

❑ Communicability

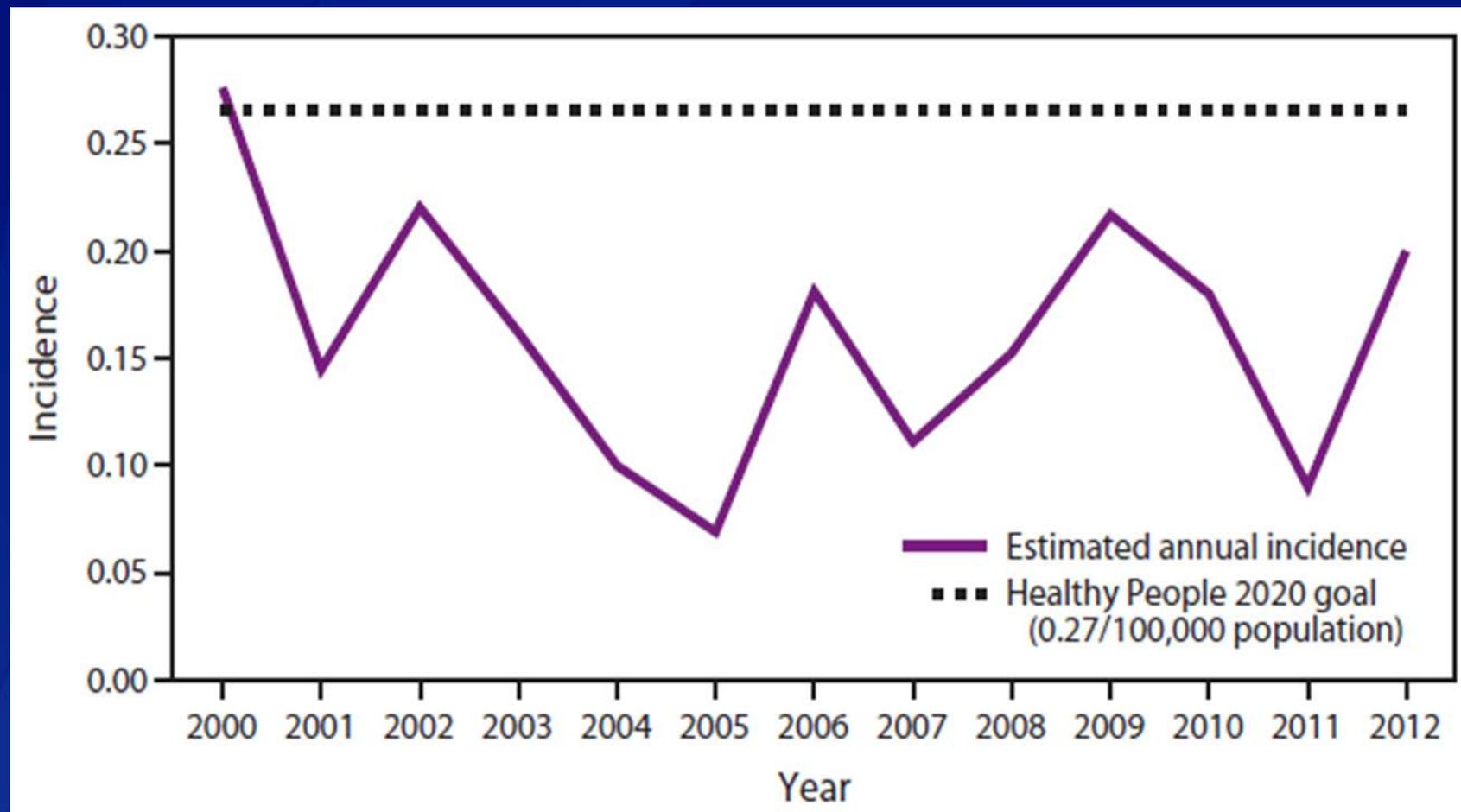
Generally limited but higher in some circumstances (e.g., household, child care)

# Estimated Annual Incidence (per 100,000) of Invasive *Haemophilus influenzae* type b (Hib) Disease in Children Aged <5 Years — United States, 1980–2012



MMWR2014;63(RR01):1-14.

## Estimated Annual incidence (per 100,000) of invasive *Haemophilus influenzae* type b Infection in Children Aged <5 Years — United States, 2000–2012



MMWR2014;63(RR1):1-14.

## *Haemophilus influenzae* type b Polysaccharide Vaccine

- ❑ 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
- ❑ 2 conjugate vaccines licensed for use in infants as young as 6 weeks of age
- ❑ 2 combination vaccines available that contain Hib vaccine

# Conjugate Hib Vaccines

## □ PRP-T

ActHIB, Pentacel,  
MenHibrix,  
Hiberix (4<sup>th</sup> dose only)

## □ PRP-OMP

PedvaxHIB

**Figure 1. Recommended immunization schedule for persons aged 0 through 18 years – United States, 2015.**

**(FOR THOSE WHO FALL BEHIND OR START LATE, SEE THE CATCH-UP SCHEDULE [FIGURE 2]).**

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Diphtheria, tetanus, & acellular pertussis <sup>3</sup> (DTaP: <7 yrs)			1 <sup>st</sup> dose	2 <sup>nd</sup> dose	3 <sup>rd</sup> dose			← 4 <sup>th</sup> dose →				5 <sup>th</sup> dose				
Tetanus, diphtheria, & acellular pertussis <sup>4</sup> (Tdap: >7 yrs)														(Tdap)		
<i>Haemophilus influenzae</i> type b <sup>5</sup> (Hib)			1 <sup>st</sup> dose	2 <sup>nd</sup> dose	See footnote 5		← 3 <sup>rd</sup> or 4 <sup>th</sup> dose, See footnote 5 →									
Pneumococcal conjugate <sup>6</sup> (PCV13)			1 <sup>st</sup> dose	2 <sup>nd</sup> dose	3 <sup>rd</sup> dose		← 4 <sup>th</sup> dose →									
Pneumococcal polysaccharide <sup>6</sup> (PPSV23)																
Inactivated poliovirus <sup>7</sup> (IPV: <18 yrs)			1 <sup>st</sup> dose	2 <sup>nd</sup> dose	← 3 <sup>rd</sup> dose →						4 <sup>th</sup> dose					
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Range of recommended ages for all children
  Range of recommended ages for catch-up immunization
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**NOTE: The above recommendations must be read along with the footnotes of this schedule.**

# Hib Vaccine

Vaccine	Birth	1 mo	2 mos	4 mos	6 mos	9 mos	12 mos	15 mos	18 mos	19-23 mos	2-3 yrs	4-6 yrs	7-10 yrs	11-12 yrs	13-15 yrs	16-18 yrs
<i>Haemophilus influenzae</i> type b <sup>s</sup> (Hib)			1 <sup>st</sup> dose	2 <sup>nd</sup> dose	See footnote 5		3 <sup>rd</sup> or 4 <sup>th</sup> dose See footnote 5									

- ❑ Recommended interval 8 weeks for primary series
- ❑ Minimum interval 4 weeks for primary series
- ❑ Minimum age 6 weeks
- ❑ Booster dose at 12-15 months

# Hib Vaccine Routine Schedule

Vaccine	2 months	4 months	6 months	12-18 months
PRP-T*	X	X	X	X
PRP-OMP	X	X	NA	X

\*Except Hiberix, which is approved only for the last (booster) dose of the Hib series

## Unvaccinated Children 7 months of Age and Older

- ❑ Children starting late may not need entire 3 or 4 dose series
- ❑ Number of doses child requires depends on current age
- ❑ See detailed schedule p. 128 of PinkBook, and 2015 catchup schedule

# Hib Vaccine

## Use in Older Children and Adults

- ❑ Generally not recommended for persons older than 59 months of age
- ❑ High risk older children and adolescents may be vaccinated if not vaccinated in childhood
  - Asplenia
  - Immunodeficiency
  - HIV infection
  - Receipt of chemotherapy or radiation therapy
- ❑ Special populations

# Guidance for Hib Vaccination in High-risk Groups

High-risk group	Hib vaccine guidance
Elective splenectomy	If unimmunized: 1 dose, prior to procedure
Asplenic patient	If unimmunized: 1 dose
HIV-infected children	If unimmunized: 1 dose
HIV-infected adults	Hib vaccination not recommended
Hematopoietic stem cell transplant	3 doses (at least 4 wks apart) beginning 6-12 mos after transplant

# Special Populations

- ❑ Children aged <24 months 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
  - PRP-OMP vaccines specifically recommended for primary series doses
  - Hib disease peaks earlier in infancy
  - PRP-OMP vaccines produce protective antibody after first dose/early protection

# **Monovalent Hib Vaccines**

- ActHIB (PRP-T)**
- PedvaxHIB (PRP-OMP)**
- Hiberix (PRP-T)**

# ActHIB (PRP-T)

- ❑ Approved for all doses of primary schedule and booster dose
- ❑ Can be used for previously unvaccinated children per the catch-up schedule.
- ❑ Must be reconstituted only with 0.4% NaCl ActHIB diluent

# PedvaxHIB (PRP-OMP)

- ❑ Approved for all doses of primary schedule and booster dose
  - Remember primary series for PRP-OMP vaccines is 2 doses
- ❑ Can be used for previously unvaccinated children per the catch-up schedule.

# Hiberix (PRP-T)

- ❑ Approved as a booster dose for children 15 months-4 years of age who have received a primary series of any Hib-containing vaccine
- ❑ Not approved for primary immunization
- ❑ May NOT be used as the ONLY Hib dose in a child who has received no prior Hib doses
- ❑ Can be used at 12-14 months of age\*

\*ACIP off-label recommendation

# Combination Vaccines Containing Hib

- **DTaP-IPV/Hib**
  - Pentacel
  
- **Hib-MenCY**
  - MenHibrix

# Pentacel

- ❑ Contains DTaP, Hib (PRP-T), and IPV
- ❑ Approved for doses 1 through 4 among children 6 weeks through 4 years of age
- ❑ Do NOT use for children 5 years or older
- ❑ Package contains lyophilized Hib (ActHIB) that is reconstituted with a liquid DTaP-IPV solution

# MenHibrix

- ❑ Contains Hib (PRP-T) and *Neisseria meningitidis* serogroups C and Y
- ❑ Approved for 4 doses between 6 weeks and 18 months of age
- ❑ Only recommended for routine meningococcal vaccination of infants who are at increased risk for meningococcal disease
  - Persistent complement pathway deficiencies
  - Anatomic or functional asplenia, including sickle cell disease

# Hib Vaccine Interchangeability

- ❑ All monovalent 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

\*Except Hiberix, which is approved only for the last (booster) dose of the Hib series

# Comvax

- ❑ Hepatitis B-Hib (PRP-OMP) combination
- ❑ Removed from existing contracts and pricing programs
- ❑ Listed as “Discontinued” on FDA website
- ❑ Unexpired vaccine can be administered

# Contraindications and Precautions

- ❑ Severe allergic reactions 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



# Polio Resources

- ❑ ACIP's Polio Recommendations web page  
[www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/polio.html](http://www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/polio.html)
- ❑ CDC's Polio Eradication web page  
[www.cdc.gov/polio/](http://www.cdc.gov/polio/)
- ❑ CDC's Polio Vaccination web page  
[www.cdc.gov/vaccines/vpd-vac/polio/default.htm](http://www.cdc.gov/vaccines/vpd-vac/polio/default.htm)
- ❑ CDC's Travel web page  
[wwwnc.cdc.gov/travel](http://wwwnc.cdc.gov/travel)
- ❑ Immunization Action Coalition Polio web page  
[www.immunize.org/polio/](http://www.immunize.org/polio/)
- ❑ Children's Hospital of Philadelphia Polio web page  
[www.chop.edu/service/vaccine-education-center/a-look-at-each-vaccine/polio-vaccine.html](http://www.chop.edu/service/vaccine-education-center/a-look-at-each-vaccine/polio-vaccine.html)



# Hib Resources

- ❑ ACIP's Hib Recommendations web page  
[www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/hib.html](http://www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/hib.html)
- ❑ CDC's Hib Infection web page  
[www.cdc.gov/hi-disease/index.html](http://www.cdc.gov/hi-disease/index.html)
- ❑ CDC's Hib Vaccination web page  
[www.cdc.gov/vaccines/vpd-vac/hib/default.htm](http://www.cdc.gov/vaccines/vpd-vac/hib/default.htm)
- ❑ Immunization Action Coalition Hib web page  
[www.immunize.org/hib/](http://www.immunize.org/hib/)
- ❑ Children's Hospital of Philadelphia Hib web page  
[www.chop.edu/service/vaccine-education-center/a-look-at-each-vaccine/hib-vaccine.html](http://www.chop.edu/service/vaccine-education-center/a-look-at-each-vaccine/hib-vaccine.html)