NCC Pediatrics Continuity Clinic Curriculum: **Immunizations**

Goal:

To understand the pediatric immunization schedule—a component of the AAP Periodicity Schedule— and become familiar with special immunization cases.

Pre-Meeting Preparation:

- Review the following enclosures:
  - Peds in Review, 2015. "Immunizations: Vaccinations in General"
  - 2018 Combined Immunization Schedule (0-18 yrs)
  - 2018 Immunization Updates (from AAP News)
  - 2018-2019 AAP Flu Update (from AAP News)
- Provide an example of a **"Vaccine Myth or Misconception"** and your thoughts about how to respond to a parent who has these concerns. *You may use the Extra-credit links or your own experiences as a guide.*

Conference Agenda:

- Complete "Immunization Cases"
- **Round-table discussion** of "Vaccine Myths & Misconceptions"—*each resident should list their example; the group should help offer ways to counsel parents.*
- **Optional:** Tour of Immunization Clinic.

Extra-Credit:

- **CDC- Vaccine Safety Concerns**; **CDC- Parents' FAQs**
- Vaccine Safety: Medical Contraindications, Myths, and Risk Communication (PIR, 2015)
- AAP & Immunizations *(vaccine-preventable diseases, vaccines & safety, etc.)*
- ACIP Vaccine Abbreviations & Trade Names *(good for decoding shot records)*

Immunizations: Vaccinations in General

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Educational Gap

Despite the great success of the national childhood immunization program, gaps in coverage remain, and vaccine-preventable diseases continue to occur.

Objectives

After completing this article, readers should be able to:

1. Describe the indications, contraindications, and schedule for each of the routine childhood immunizations.
2. Recognize the enhanced immunogenicity of conjugate vaccines.

INTRODUCTION

Immunization is one of the most frequent, complex, and costly activities in the pediatric office. The routine childhood immunization schedule published by the Centers for Disease Control and Prevention (CDC) has burgeoned from vaccines protecting against nine diseases, supplemented by one-half page of explanatory footnotes, 2 decades ago to 16 diseases, three pages of footnotes, and a host of combination vaccines in 2014. Although electronic health record decision support holds promise for streamlining vaccine administration, currently pediatricians must rely on intimate knowledge of immunizations and ready access to resources that address the nuances of the schedule and other special considerations such as contraindications and precautions.

This article reviews the routine childhood vaccine schedule, contraindications and precautions to immunization, and common special considerations in immunization. A full discussion of special circumstances and high-risk populations is beyond the scope of this review. A companion article in this issue of *Pediatrics in Review* — "Vaccine Safety: Medical Contraindications, Myths and Risk Communication," by Dr Michael Smith — addresses vaccine hesitancy and catch-up schedules for unimmunized and underimmunized children.

GENERAL CONCEPTS

The childhood immunization schedule is reviewed, updated, and approved annually by the Advisory Committee on Immunization Practices (ACIP), the American Academy of Pediatrics, and the American Academy of Family Practice. The schedule is published annually in the *Morbidity and Mortality Weekly Report*. The CDC Recommended Immunization Schedule for Persons Aged 0 through 18

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years – United States 2015, catch-up schedules, and adult immunization schedules are available at www.cdc.gov/vaccines/schedules. The recommended schedule takes into account available evidence regarding vaccine efficacy and safety, immunogenicity (including persistence of passive maternal antibody), and disease prevalence. Although standard recommended intervals should be followed routinely to maximize protection, minimal intervals may be used to "catch up" children with delayed immunizations or if there is concern that a child may not return.

Timeliness of immunization is a challenge. A 2002 study demonstrated that by the age of 24 months, approximately 90% of children had received at least one vaccine late or too early to be considered valid. (1) When immunization is delayed, no routine immunization dose needs to be repeated. For immunizations administered too early, the dose should be repeated at the recommended minimum age and interval following the invalid dose. In accordance with ACIP guidelines, vaccines given within a grace period of 4 or fewer days below the minimum interval may be accepted as valid, but local and state regulations may not recognize this exception.

Most vaccines may be administered simultaneously, but when live vaccines are not given simultaneously, administrations should be separated by at least 28 days. Antigenic content of various vaccine products varies and evidence concerning the interchangeability of products is limited. The same product should be continued if practical, but vaccines should not be delayed if the same product is not available.

Other than local reactions and fever, adverse events to immunization are relatively rare. Parents should be counseled about possible adverse events and provided with the current Vaccine Information Statements published by the CDC. Significant adverse events should be reported to the CDC through the Vaccine Adverse Event Reporting System. (2)

Vaccines should not be administered in the presence of a true contraindication. Only one contraindication is common to all vaccines: anaphylaxis to a previous dose or vaccine component. When a precaution is present, immunization is generally deferred. However, vaccines may be given if the benefit outweighs the risk (eg, community outbreak). The only precaution to all vaccines is moderate-to-severe acute illness at the time that the immunization is due. In these situations, immunization may resume as the acute illness begins to resolve. Deferring vaccines in the absence of true contraindications or precautions (eg, during minor illness) is an important cause of missed opportunities for immunization.

Most routine childhood vaccines contain inactivated subunit antigens or toxins. The introduction of conjugate vaccine technology has been an important advance in the protection of children younger than 2 years of age as well as immunocompromised individuals. Bacterial polysaccharides, which are poorly immunogenic in younger children, are conjugated to carrier proteins (typically capsular or outer membrane antigens). These proteins improve immune responsivity by triggering T-cell-dependent immunity to polysaccharides, thereby strengthening immune memory.

Live attenuated vaccines include vaccines against measles-mumps-rubella (MMR), varicella, rotavirus, and influenza. Live vaccines generally induce stronger mucosal immunity than inactivated products. Because viral replication occurs, live vaccines are generally contraindicated in immunocompromised patients, in pregnancy, and following recent receipt of antibody-containing blood products (up to 11 months, depending on the dose of antibody received).

INFLUENZA VACCINES

Immunization against influenza poses unique challenges because of the changing circulation of antigenically distinct influenza viruses from year to year. Antigenic drift, due to continual minor influenza virus mutations, is particularly common among influenza A strains. In contrast, antigenic shift introduces a markedly novel influenza strain following a sudden major change in antigens to which there is little or no preexisting immunity in the population. (3) Antigenic shift is much less common than antigenic drift but has the potential to result in pandemics (eg, Spanish flu of 1918 and H1N1 in 2009).

Influenza vaccine is developed annually based on the antigenic composition of strains predicted to circulate most widely in the coming year. Trivalent vaccine historically included one B strain and two A strain lineages. Beginning with the 2013-2014 season, quadrivalent influenza vaccine became available to cover both influenza B strain lineages. In the prior 10 years, the circulating B strain was included in the trivalent vaccine in only 50% of seasons. (3) Quadrivalent influenza vaccines eventually should replace trivalent vaccines.

Childhood influenza immunization historically targeted children 6 months to 2 years of age, who experience severe illness and death at rates similar to other high-risk groups (such as adults >65 years of age), and children with chronic illnesses, including persistent asthma and other chronic respiratory diseases as well as cardiac, neurologic, metabolic, hepatic, renal, and immunologic disorders. However, routine influenza immunization for all children older than 6 months of age has been recommended since 2010. This recommendation is based on the following observations:

- Excess severe illness burden also occurs in children ages 2 to 5 years.

- Influenza causes preventable severe illness and death in previously healthy older children and young adults.
- Influenza immunization confers health benefits for all age groups.
- Children serve as a vehicle of transmission of influenza to unimmunized and unprotected individuals, including very young infants, immunocompromised individuals, and patients with contraindications to immunization.

Immunization of all health-care personnel and office staff is essential to protect vulnerable patients and to keep staff healthy and available to treat patients during community outbreaks. To ensure patient protection, compliance with annual influenza immunization is a condition of employment at many health-care facilities.

Influenza vaccine is administered annually to children ages 6 months and older, beginning as soon as vaccine becomes available. Although waning immunity late in the season is a consideration, missed opportunities to immunize and the challenging logistics of immunizing large numbers of patients in a narrow window of time support early immunization. Continuing immunization throughout the influenza season is also advised (Table 1).

Children ages 9 years and older require one dose of influenza vaccine annually. Younger children receiving either live or inactivated vaccine may require two doses separated by at least 28 days; recommendations vary from year to year. Currently, two doses are indicated if the child has not received two doses before the start of the current influenza season. The only exception to this rule is children who received one dose of influenza vaccine in the 2013-2014 season, who need only one dose in the 2014-2015 season. Because H1N1 has continued to circulate since the 2009-2010 season, children younger than 9 years also need two doses in the current season if at least one prior dose did not contain H1N1 antigen. H1N1 antigen has been included in all vaccines since 2010 and in monovalent H1N1 vaccine during the 2009-2010 season.

There are few true contraindications to influenza vaccine. Both inactivated and live attenuated influenza vaccines are contraindicated in patients with severe egg allergy. Patients with mild egg allergy without anaphylaxis may receive inactivated influenza vaccine, followed by 30 minutes of in-office observation.

A small increase in the risk of febrile seizures among children ages 6 months to 5 years has been observed in some seasons, particularly with simultaneous administration of pneumococcal conjugate vaccine. Although surveillance for an association between influenza vaccine and febrile seizures continues, current recommendations have not changed. However, one brand of influenza vaccine was more definitively associated with increased incidence of febrile seizures (Afluria, Merck and Co, Inc, Whitehouse Station, NJ) and is not routinely recommended for children younger than 9 years of age. (3)

Guillain-Barré syndrome (GBS) was associated with the 1976 swine influenza vaccine, but recent studies suggest at most a small increased risk of GBS following influenza immunization (approximately 1 additional case per 1 million doses). (4) Immunization of patients with a past history of GBS deserves careful consideration; the potential small increased risk of recurrent GBS must be balanced against the risk of influenza disease, particularly in individuals with other high-risk conditions.

Quadrivalent live attenuated influenza vaccine (LAIV4) has a similar safety profile and efficacy as compared to inactivated influenza vaccine, and is an option for healthy children 2 years of age and older. Adverse events following LAIV4 administration are uncommon and include minor respiratory and gastrointestinal symptoms such as

TABLE 1. **Influenza Vaccines Approved for Use in Children 6 Months to 17 Years of Age, 2014-2015 Season**

TRADE NAME	MANUFACTURER	FORMULATION	AGES INDICATED	ROUTE
Fluzone	Sanofi Pasteur	IIV3, IIV4, inactivated	≥6 mo	Intramuscular
FluMist	MedImmune	LAIV4, live attenuated	≥2 y (to 49 y)	Intranasal
Fluarix	GlaxoSmithKline	IIV3, IIV4, inactivated	≥3 y	Intramuscular
FluLaval	ID Biomedical Corporation of Quebec	IIV3, IIV4, inactivated	≥3 y	Intramuscular
Fluvirin	Novartis Vaccines and Diagnostics	IIV3, inactivated	≥4 y	Intramuscular
Afluria	CSL Limited	IIV4, inactivated	≥5 y*	Intramuscular

**American Academy of Pediatrics does not recommend routine use before age 9 years due to risk of febrile seizures.*

rhinorrhea, cough, abdominal pain, and fever. LAIV4 is contraindicated in pregnancy, egg allergy, and immunosuppression; in recipients of antiviral agents in the preceding 48 hours; and in children being treated with aspirin. Asthma and other underlying conditions that might be associated with a higher risk of influenza complications are precautions for LAIV4 due to the lack of safety evidence in affected patients. Children 2 to 4 years of age who have a history of wheezing in the last 12 months also should not receive LAIV4. Contacts of immunosuppressed patients may receive LAIV4, with the exception of caregivers of individuals with severe immunosuppression requiring a protected environment (eg, bone marrow transplant unit).

CONJUGATE VACCINES

Meningococcal Vaccines

Two quadrivalent conjugate vaccines (Menactra [MCV4-D], Sanofi Pasteur, Inc, Swiftwater, PA and Menveo [MCV4-CRM], Novartis Vaccines, Cambridge, MA) are currently available to protect against meningococcal strains A/C/Y and W-135. Nearly 75% of meningococcal infections in children 11 years and older involve these strains. (5) Two nonconjugate vaccines targeting serogroup B have recently been licensed for children and young adults ages 10–25 years (Bexsero, Novartis and Trumenba, Wyeth Pharmaceuticals Inc, Philadelphia, PA). Bexsero is administered in two doses one month apart; Trumenba requires three doses at 0, 2, and 6 months. While these vaccines have been used in outbreaks in New Jersey, California, Rhode Island, and Oregon, formal recommendations for use have not yet been published. Indications will likely include outbreak control and immunocompromise (complement deficiencies and asplenia). (6)

Conjugate meningococcal vaccines are preferred due to strong anamnestic responses to a subsequent booster dose, reduced nasopharyngeal carriage of meningococcus, and longer duration of clinical protection. (7) Quadrivalent meningococcal polysaccharide vaccine (Menomune [MPSV4], Sanofi) may be used when there is a contraindication to MCV4 (eg, severe allergy to diphtheria toxoid). Immunization is recommended at 11 to 12 years of age, with a booster dose at 16 to 18 years of age, at least 8 weeks after the first dose. Cases of meningococcal disease and deaths are significantly fewer with this two-dose regimen. Individuals receiving a first dose of vaccine at 16 years of age or older do not require a second dose, but unimmunized college freshman living in dormitories and those who received a single dose before age 16 years should receive one dose of vaccine. There has been a small increase in GBS clustered 14 days after administration of Menactra (but not Menveo). The risk of GBS is outweighed by the benefit of protection against meningococcal disease. Accordingly, a prior history of GBS was removed as a precaution to meningococcal vaccination in 2010. (6)

Routine immunization of children younger than 11 years of age is not recommended. Recommendations for meningococcal immunization for patients at increased risk vary with patient age and the specific indication for immunization (eg, potential exposure vs immune compromise). (7) In general, two doses of MCV4 separated by 8 to 12 weeks are recommended for children 2 years of age and older with immunodeficiency and adolescents 11 years of age or older with human immunodeficiency virus (HIV) infection. Only MCV4-D is approved for infants 2 to 9 months old at increased risk of meningococcal disease; either conjugate vaccine may be administered to infants and children older than 9 months. Children with functional or anatomic asplenia, including sickle cell disease, should not receive MCV4-D until after 2 years of age due to immune interference with 13-valent pneumococcal conjugate vaccine (PCV13). (7)

HibMenCY (MenHibrix, GlaxoSmithKline Biologicals, Rixensart, Belgium) is a bivalent meningococcal vaccine conjugated to *Haemophilus influenzae* b (Hib) that protects against strains C and Y. It is approved as a four-dose series for infants 6 weeks to 18 months of age at high risk due to functional or anatomic asplenia (including sickle cell disease), complement deficiencies, or exposure due to local outbreaks. When infants are immunized with HibMenCY, this vaccine should be used for all four doses, and other Hib-containing vaccines should not be given. For high-risk children 2 to 6 years of age, a booster dose with MCV4 is required 3 years after the primary series. Thereafter, and for children 7 years of age and older, a booster of MCV4 is required every 5 years. (7)

Pneumococcal Vaccines

Streptococcus pneumoniae is an important cause of respiratory tract disease (pneumonia, sinusitis, and otitis media), bacteremia, and meningitis. In 2010, PCV13 replaced the former 7-valent vaccine. The polysaccharide capsular antigens in PCV13 are individually conjugated to a diphtheria membrane protein. PCV13 is indicated for immunization of healthy children at 2, 4, 6, and 12 to 15 months of age as well as children and adults with immune compromise and other conditions that increase the risk for invasive pneumococcal disease. (8) Healthy children 15 to 59 months of age and children with underlying medical conditions younger than 72 months of age who were previously fully immunized with PCV7 should receive one dose of PCV13. Older children with immune compromise and other specific high-risk conditions for invasive disease (eg, cochlear implants,

cerebrospinal fluid leaks, and asplenia) should be immunized with one dose of PCV13 if not previously immunized.

A nonconjugate, 23-valent pneumococcal vaccine (PPS23) is also available for high-risk patients to protect against the 13 serotypes in PCV13 as well as 10 additional serotypes. PPS23 is poorly immunogenic in children younger than 24 months of age and is not used in this age group. PPS23 is indicated for patients 2 years of age and older with the following conditions:

- Chronic illnesses such as chronic lung disease (including asthma for those 19 years and older)
- Chronic cardiac, renal, and hepatic disease and diabetes
- Immunocompromising conditions such as sickle cell disease, HIV, and malignancy

For immunocompromised patients, PPS23 should be administered at least 8 weeks following a dose of PCV13. In childhood, only one additional dose of PPS23 is recommended, 5 years after the first dose (eg, for children with timely immunizations, PPS23 is administered at 2 years and 7 years). Pneumococcal vaccine administration is nuanced in patients with chronic disease and immunocompromise, and the reader is directed to the references for additional information. (8)(9)

Haemophilus Influenzae Type B Vaccines

Hib was a leading cause of bacteremia, meningitis, cellulitis, and epiglottitis in the prevaccine era. Hib capsular antigen is conjugated to either a tetanus or *Neisseria meningitidis*-derived carrier protein. Hib vaccine is given in three or four doses (determined by brand) at 2, 4, (6) and 12 to 15 months, either as a monovalent vaccine or in combination with diphtheria-tetanus-acellular pertussis-inactivated poliovirus. A single dose is sufficient for children ages 15 to 59 months of age who have delayed immunizations; a catch-up schedule is available for younger children with incomplete immunizations. Immunization may also be indicated for some older children with immune compromise. Adverse events following Hib vaccine are uncommon and largely limited to minor local reactions.

NONCONJUGATE INACTIVATED VACCINES

Hepatitis Vaccines

Hepatitis B infection is a common cause of acute and chronic liver disease, hepatocellular carcinoma, and death worldwide. Hepatitis B vaccine, composed of recombinant DNA-produced hepatitis B surface antigen (HBsAg), was the first vaccine to provide protection against cancer through prevention of infection with hepatitis B virus. Hepatitis B infection in newborns is rarely symptomatic but results in a chronic carrier state in more than 90% of infected infants. Prompt neonatal immunization is highly efficacious in preventing neonatal acquisition of hepatitis B. Therefore, for infants weighing at least 2 kg, hepatitis B vaccine is administered at birth, 1 to 2 months, and 6 months of age, with catch-up for unimmunized older children. Combination vaccines should not be used for the birth dose. The final dose should be provided no earlier than 24 weeks of age, at least 8 weeks following the second dose and at least 16 weeks following the first dose. For preterm infants weighing less than 2 kg, hepatitis B immunization is deferred until the infant reaches 1 month of age or hospital discharge (whichever comes first), unless the mother is HBsAg-positive or her status is unknown. In these situations, hepatitis B vaccine is given at birth, but the dose is not "counted" and is repeated when the infant reaches 1 to 2 months of age. (10)

Hepatitis B immune globulin (HBIG) is coadministered with hepatitis B vaccine within 12 hours of birth to infants born to hepatitis B-infected mothers and to preterm infants weighing less than 2 kg if the mother's results will not be available by 12 hours of age. For infants weighing more than 2 kg, HBIG administration may be deferred for up to 7 days or until the mother is determined to be HBsAg-positive. HBIG should be administered no later than 7 days after birth if the mother's results remain unavailable. Original maternal laboratory reports should be viewed directly; failure to recognize maternal hepatitis B infection and deferral of immunization outside of the perinatal period have been associated with preventable neonatal hepatitis B infection and rare deaths from fulminant neonatal hepatitis B. Infants born to HBsAg-positive mothers should be tested for hepatitis B surface antibody and HBsAg following the final dose of hepatitis B vaccine (typically at 9 to 12 months).

Hepatitis A infection is also an important cause of preventable liver disease. Two single-antigen inactivated hepatitis A vaccine (HAV) products are currently available for use in children: Havrix (GlaxoSmithKline) and VAQTA (Merck and Co, Inc). HAV is recommended for all children 12 months of age, with a booster dose 6 to 18 months later and catch-up for older children. Immunization is also recommended for household contacts of children adopted from countries with moderate-to-high rates of hepatitis A infection (currently applies to most international adoptees). Adverse events are uncommon. HAV and hepatitis A immune globulin are recommended for postexposure prophylaxis for unimmunized patients.

Diphtheria, Pertussis, and Tetanus Vaccines

Pertussis illness has a variety of presentations, including a nondescript upper respiratory tract infection, the classic

triphasic "100-day cough" syndrome, pneumonia, apnea (in young infants), seizures, and encephalopathy, with mortality occurring predominantly in infants. Tetanus is characterized by severe muscle spasms provoked by a neurotoxin, often progressing to respiratory failure. Diphtheria infection causes an acute membranous pharyngitis that may lead to airway obstruction. Although diphtheria and tetanus are now rare in the United States, pertussis infections remain endemic, with cyclic peaks occurring every 3 to 5 years.

Acellular pertussis vaccines have entirely replaced whole-cell pertussis vaccines. Although acellular pertussis vaccines contain varying pertussis antigens and quantities (Table 2), currently available products are believed to be equivalent in efficacy and safety. These products are associated with fewer adverse effects than whole-cell pertussis vaccines, but recent data also suggest a more rapid decline in immune protection following immunization with acellular pertussis vaccine. (11) Reported cases of pertussis have been increasing, particularly among children 10 years of age and older. Complete protection against pertussis is 98% at 1 year following the fifth dose of pertussis-containing vaccine, declining to 70% at 5 or more years following immunization.

Diphtheria-tetanus-acellular pertussis (DTaP) vaccine is administered in a five-dose series at 2, 4, and 6 months of age; at 15 to 18 months (at least 6 months following the third dose); and upon school entry (4-6 years). Only four doses are required if the fourth dose is given after 4 years of age. DTaP is often administered as a component of combination vaccines containing inactivated polio vaccine (IPV) and Hib or hepatitis B vaccine. DTaP and diphtheria-tetanus (DT) are not recommended for children 7 years or older.

Beginning in 2005, a single dose of Tdap replaced Td for adolescents 11 to 18 years of age. Since 2010, ACIP has also recommended a single dose of Tdap for unimmunized/underimmunized children 7 to 10 years of age due to lack of a licensed pertussis-containing vaccine for this age group. (12) Tdap is preferred for children 7 years of age and older because it is less reactogenic than DTaP (due to its reduced diphtheria and pertussis antigenic content) (Table 2). A single dose of Tdap is followed by up to three doses of Td for children who require additional doses to complete the routine series.

When indicated, Tdap may be administered with no minimum interval following the last dose of DTaP, DT, or Td. To achieve high antibody concentrations during pregnancy and passive protection of the newborn, mothers should be immunized with Tdap during each pregnancy, preferably during the third trimester. (13) With the exception of pregnancy, no booster doses of Tdap are recommended; subsequent doses should be administered as Td. Booster doses of Tdap may be recommended in the future as additional long-term safety and efficacy data become available.

A booster dose of a tetanus-containing vaccine is recommended for patients with clean wounds incurred 10 or more years since their last tetanus dose and for major or contaminated wounds seen 5 or more years since the last dose. Vaccine should also contain diphtheria and pertussis

TABLE 2. **Comparison of Selected Diphtheria and Pertussis-containing Vaccines**

TRADE NAME	DAPTACEL DTaP	INFANRIX DTaP	KINRIX DTaP-IPV	ADACEL Tdap	BOOSTRIX Tdap	PENTACEL DTaP-IPV-HIB	PEDIARIX DTaP- IPV-HEP B
Manufacturer	Sanofi Pasteur	GlaxoSmithKline	GlaxoSmithKline	Sanofi Pasteur	GlaxoSmithKline	Sanofi Pasteur	GlaxoSmithKline
Age approved	6 wk – 6 y	6 wk – 6 y	4 – 6 y	10 – 64 y	≥10 y	6 wk – 4 y	6 wk – 6 y
Tetanus toxoid	5 Lf	10 Lf	10 Lf	5 Lf	5 Lf	5 Lf	10 Lf
Diphtheria toxoid	15 Lf	25 Lf	25 Lf	2 Lf	2.5Lf	15 Lf	25 Lf
Pertussis Antigens:							
Filamentous hemagglutinin	5 μg	25 μg	25 μg	5 μg	8 μg	20 μg	25 μg
Inactivated pertussis toxin	10 μg	25 μg	25 μg	2.5 μg	8 μg	120 μg	25 μg
Pertactin	3 μg	8 μg	8 μg	3 μg	2.5 μg	3 μg	8 μg
Fimbriae Types 2 & 3	5 μg	-	-	5 μg	-	5 μg	-

Lf=limit of flocculation (units)

antigens, unless specifically contraindicated. Tetanus immune globulin is indicated only in isolated circumstances: massive or contaminated wounds in patients with unknown immunization status or who received fewer than three doses of tetanus-containing vaccine, persons with HIV or other severe immunocompromise regardless of immunization status, and potential umbilical cord contamination in an infant born to an unimmunized mother outside of a hospital. (14)

The most common reactions to DTaP are local and febrile. A temperature greater than 40.5°C (104.9°F), seizures, hypotonic-hyporesponsive episodes, and inconsolable crying are much less common after DTaP than was observed for whole-cell pertussis vaccine, but such occurrences represent precautions to subsequent doses of DTaP. These events are not associated with later epilepsy or other sequelae. Current evidence does not support a causal relationship between acellular pertussis vaccines and acute neurologic illness, but encephalopathy within 7 days of receipt of any pertussis-containing vaccine remains a contraindication to further pertussis immunization. Vaccination is typically deferred in young infants with evolving neurologic illnesses. If the indication for deferral persists beyond 1 year of age, immunization with DT is recommended up to the age of 7 years, after which time Td is advised. GBS and brachial neuritis are rare adverse events following tetanus toxoid administration but not after DTaP. GBS occurring within 6 weeks following Td or Tdap is a precaution to further doses. Generally, Td or Tdap are not administered in such situations, but individual circumstances should be considered.

Polio Vaccines

Polio vaccine has eliminated paralytic polio from the Western Hemisphere. Only IPV is available in the United States, due to the small but avoidable risk of vaccine-associated paralytic poliomyelitis caused by the live attenuated vaccine strain. The possibility of transmission of vaccine virus to unimmunized or immunocompromised household contacts is also eliminated by use of IPV.

IPV is administered in a four-dose series at 2, 4, 6 to 18 months, and 4 to 6 years of age. Only three doses are required if the third dose is given after 4 years of age, provided that at least 6 months have elapsed since the second dose. IPV is well tolerated and adverse events are rare. Adults are generally presumed to be immune to polio and are only immunized if they are at increased risk of infection (eg, travelers and those with occupational exposures).

Human Papillomavirus Vaccines

Approximately 40 types of human papillomaviruses (HPVs) infect humans, predominantly through sexual contact. The spectrum of illness ranges from asymptomatic infection to genital warts, genital cancers (particularly cervical cancer), anal and head-and-neck cancers, and rarely, laryngeal papillomatosis (via vertical transmission during vaginal delivery). Two licensed vaccines (Gardasil, Merck and Co, Inc, and Cervarix, GlaxoSmithKline) provide protection against HPV types 16 and 18, which together cause approximately 70% of cervical cancers. Gardasil also provides protection against types 6 and 11, which cause 90% of genital warts. (15) Immunization is recommended routinely for both boys and girls at age 11 to 12 years, ideally before initiation of sexual activity. (16) A newly licensed 9-valent HPV vaccine (Gardasil 9, Merck and Co, Inc) targets the four HPV types in Gardasil, as well as types 31, 33, 45, 52, and 58; these additions extend coverage to approximately 90% of cervical cancer cases. (17) Recommendations for series completion and reimmunization for recipients of Gardasil have not yet been released. HPV immunization can be initiated as early as age 9 years and up to 26 years for those not previously immunized. For all three formulations, three doses are administered, with subsequent doses given 2 months and 6 months following the first dose. Because Gardasil contains *Saccharomyces cerevisiae*, it is contraindicated for those with allergy to baker's yeast. Data on vaccination during pregnancy are limited and, therefore, immunization during pregnancy is not recommended. Observation of patients for 15 minutes following vaccination is advised due to an association with syncope. Syncope is not a contraindication to future administration of any vaccine.

LIVE VACCINES

Measles-Mumps-Rubella Vaccines and Varicella Vaccine

Measles, mumps, and rubella have been largely eliminated from the United States. However, a record-breaking resurgence of measles occurred in 2014, with most case reports related to international travel and importation of disease by unimmunized individuals, followed by spread in unimmunized/underimmunized communities. (18) Varicella infection (chickenpox), varicella meningoencephalitis, and secondary complications of cellulitis and pneumonia have also declined. Because approximately 5% to 10% of individuals fail to seroconvert following immunization, two doses of MMR and varicella are given in childhood (at 12 months and 4 to 6 years of age). However, cases of measles, mumps, and varicella do occur, even in patients who have received two doses of vaccine. (18)(19) The minimum interval between doses is 28 days for MMR and varicella vaccine given at 13 years of age and older and 3 months for measles-

TABLE 3. Additional Vaccines Indicated for Certain International Travelers

VACCINE	TYPE	AGE INDICATED	SCHEDULE	BOOSTER[1]
Japanese encephalitis	Inactivated	≥2 mo	2 doses 28 d apart	Duration of protection unknown, possibly boost after 1–2 y in adults
Measles[2]	Live attenuated	≥12 mo 6 – <12 mo	2 doses at least 28 d apart Single dose	Not needed After 12 mo of age: 2 doses at least 28 d apart
Meningococcal	Inactivated	2 – 18 mo 7 – 23 mo 9 – 23 mo ≥24 mo	2, 4, 6, and 14–15 mo 2 doses 3 mo apart (MCV4-CRM[3]) 2 doses 3 mo apart, (MCV4-CRM or MCV4-D[4]) 1 dose MCV4	1 dose in 3 y; then every 5 y thereafter As above As above Every 5 y
Polio[5]	Inactivated	≥6 wk	If needed, accelerated schedule, doses #2 and #3 in ≥4-wk intervals, #4 ≥6 mo	One dose after 4 y of age, one dose <12 mo before leaving polio-infected or polio-exporting country
Rabies	Inactivated	All	Day 0, 7, 21, or 28	Depends on risk, yes if exposed
Typhoid fever	Live attenuated Inactivated	≥6 y ≥2 y	Day 0, 2, 4, 6 1 dose	Every 5 y Every 2 y
Yellow Fever	Live attenuated	≥9 mo	1 dose	Every 10 y

[1]*If risk continues.*
[2]*Given as MMR in United States; monovalent measles vaccine may be available in other countries.*
[3]*MCV4-CRM:Quadrivalent meningococcal conjugate vaccine (Menveo)*
[4]*MCV4:Quadrivalent meningococcal vaccine (Menactra)*
[5]*Series may be continued in other countries if needed as inactivated polio vaccine or live attenuated oral polio vaccine.*
Wallace GS, Seward JF, Pallanasch MA. Interim CDC guidance for polio vaccination for travel to and from countries affected by wild poliovirus. Morb Mortal Wkly Rep. *2014;63(27):591-594.*[25]

mumps-rubella-varicella (MMRV) (ProQuad, Merck and Co, Inc), and varicella vaccine given to children younger than 13 years of age. Immunization may be accomplished by administering the trivalent MMR and monovalent varicella vaccines separately (but simultaneously) or MMRV to children younger than 13 years. Because MMRV is associated with a higher risk of febrile seizures than MMR, children with a personal or family history of seizure should generally be immunized with MMR and varicella separately for the first dose. (20) Varicella vaccine is contraindicated in individuals with neomycin or gelatin allergy. Egg allergy is not a contraindication because MMR is derived from tissue culture.

During outbreaks, age-appropriate receipt of recommended vaccine should be assured. Postexposure prophylaxis may be efficacious in reducing measles and varicella infection (but not rubella or mumps) if administered within 72 hours of exposure. Potentially exposed children 13 months and older may be given a second dose of vaccine at least 28 days following receipt of the first dose. MMR can be administered to infants at least 6 months of age who are at increased risk of exposure, including international travelers. Because the immune response may be reduced in this age group, a dose of MMR administered before 12 months of age is not counted as one of the two required doses. The role of a third dose for outbreak control is an area of investigation and is not routinely recommended at present.

MMR and varicella vaccines are not recommended in pregnancy, and pregnancy should be avoided for 28 days following receipt of these vaccines. (20) If either vaccine is inadvertently given, termination of the pregnancy is not specifically advised, but the mother should be counseled that there is a theoretical risk of harm to the fetus. Prior history of idiopathic thrombocytopenic purpura is a precaution to MMR vaccine because affected individuals may be at increased risk for recurrence following immunization. As live attenuated vaccines, MMR and varicella vaccines are not

TABLE 4. Resources for International Travel

CDC Travelers Health Website: www.cdc.gov/travel/
CDC : 1-800-CDC-INFO
CDC Yellow Book: Health Information for International Travel, 2014 (updated every 2 years)
World Health Organization: www.who.int/ith/

recommended for use in immunocompromised individuals, except those with HIV who do not have severe immunosuppression. Measles inclusion body encephalitis has been described rarely in individuals with immunodeficiency. (20) Zoster (shingles) may occur following varicella vaccine administration, but the risk is greatly reduced compared to zoster following wild-type chickenpox, and symptoms are substantially milder.

Varicella immune globulin should be administered as soon as possible (up to 10 days following exposure) to high-risk individuals exposed to varicella virus. High-risk individuals include nonimmune pregnant women, neonates born to mothers with varicella infection from 5 days prior to 2 days after delivery, all hospitalized preterm infants born before 28 weeks' gestation or whose birthweight is 1,000 g or less, and hospitalized preterm infants 28 weeks' gestation or older born to nonimmune mothers. (21)

Rotavirus Vaccines

Rotavirus vaccine is indicated for the prevention of acute diarrheal disease due to rotavirus infection in healthy infants. The vaccine is administered orally on a two-dose (Rotarix, GlaxoSmithKline) or three-dose schedule (Rotateq, Merck and Co, Inc) at 2, 4, (and 6) months of age. The first dose should not be administered after 14 weeks and 6 days of age, and the final dose should not be administered after 8 months of age. Another rotavirus vaccine, RotaShield (Wyeth Laboratories, Inc, Marietta, PA), was withdrawn from the market in 1999 due to an association with intussusception. Reports of intussusception with current rotavirus vaccine cluster 3 to 7 days following the first dose only. (22) The increased risk of intussusception is estimated at 1 to 5 per 100,000 doses. In contrast, rotavirus vaccine prevents 40,000 hospitalizations in the United States annually. Rotavirus vaccine is contraindicated in patients with a history of intussusception due to increased risk of recurrence in this group (23) and in patients with severe combined immunodeficiency. (24)

VACCINES FOR INTERNATIONAL TRAVELERS

Travelers should allow at least 8 weeks before international travel to accomplish appropriate health planning and allow sufficient time for development of immune protection from vaccines. (26) International travelers should be up to date with all routine immunizations. Additional vaccines (Table 3) or immune globulin may be indicated under special circumstances. Yellow fever vaccine is only available at designated clinics, and cholera and tickborne encephalitis vaccines are currently not available in the United States. Child age, duration of travel, season, presence of infectious disease outbreaks, and contact with local populations (eg, home stay with relatives vs resort accommodations) may influence immunization decisions. The CDC provides excellent, regularly updated resources to assist with immunization and other health considerations for travel planning (Table 4). Consultation with an infectious disease specialist or travel clinic may also be of benefit, particularly for travel to higher-risk areas such as developing countries. In general, written documentation of vaccines administered outside of the United States may be considered valid.

Summary

- The childhood immunization schedule is complex and nuanced. Although serious adverse reactions to immunizations are uncommon, clinicians must be well-versed in these reactions as well as the contraindications and precautions to each vaccine.
- Conjugate vaccine technology links polysaccharide antigens to carrier proteins, triggering T-cell-dependent immunity to polysaccharides, thereby strengthening immune memory.
- On the basis of some research evidence and consensus, live vaccines are generally contraindicated in immunocompromised patients and in pregnancy. (8)(20) Most live vaccines can be administered to household contacts of immunocompromised patients. (8)(20)
- On the basis of some research and consensus, modified administration of meningococcal, pneumococcal, and less commonly, other vaccines may be indicated to protect immunocompromised patients. (2)(3)(7)(8)(20)
- On the basis of disease epidemiology and consensus, international travelers should be up-to-date with all routine immunizations; depending on destination, additional vaccines or immune globulin may be required. (26)

RESOURCES FOR HEALTH-CARE PROFESSIONALS AND FAMILIES:

American Academy of Pediatrics: www.healthychildren.org
Centers for Disease Control and Prevention: www.cdc.gov/vaccines
Immunization Action Coalition: www.immunize.org

References for this article are at http://pedsinreview.aappublications.org/content/36/6/249.full.

Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger, UNITED STATES, 2018

- Consult relevant ACIP statements for detailed recommendations (www.cdc.gov/vaccines/hcp/acip-recs/index.html).
- When a vaccine is not administered at the recommended age, administer at a subsequent visit.
- Use combination vaccines instead of separate injections when appropriate.
- Report clinically significant adverse events to the Vaccine Adverse Event Reporting System (VAERS) online (www.vaers.hhs.gov) or by telephone (800-822-7967).
- Report suspected cases of reportable vaccine-preventable diseases to your state or local health department.
- For information about precautions and contraindications, see www.cdc.gov/vaccines/hcp/acip-recs/general-recs/contraindications.html.

Approved by the

Advisory Committee on Immunization Practices
(www.cdc.gov/vaccines/acip)

American Academy of Pediatrics
(www.aap.org)

American Academy of Family Physicians
(www.aafp.org)

American College of Obstetricians and Gynecologists
(www.acog.org)

This schedule includes recommendations in effect as of January 1, 2018.

The table below shows vaccine acronyms, and brand names for vaccines routinely recommended for children and adolescents. The use of trade names in this immunization schedule is for identification purposes only and does not imply endorsement by the ACIP or CDC.

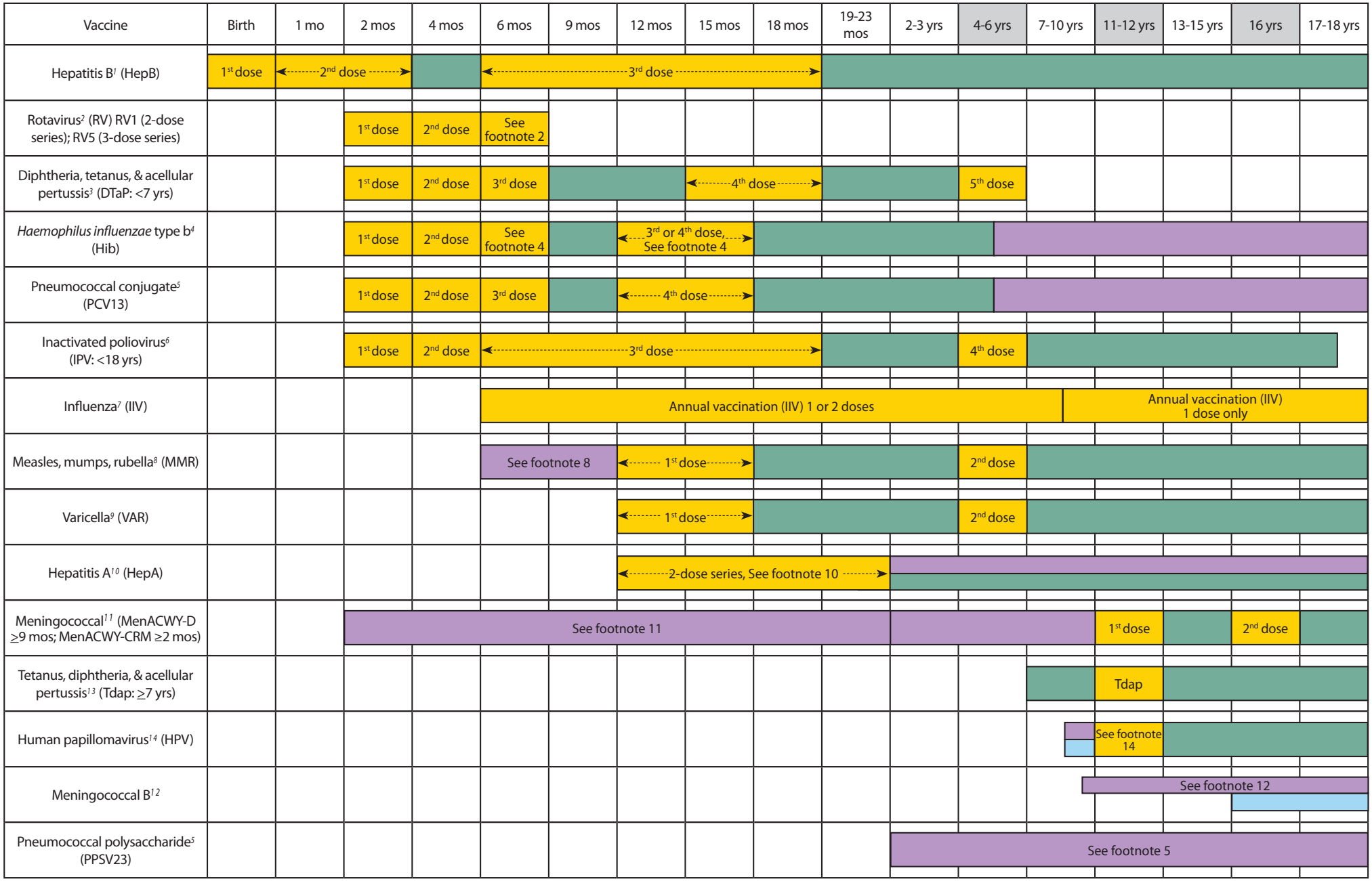
Vaccine type	Abbreviation	Brand(s)
Diphtheria, tetanus, and acellular pertussis vaccine	DTaP	Daptacel Infanrix
Diphtheria, tetanus vaccine	DT	No Trade Name
Haemophilus influenzae type B vaccine	Hib (PRP-T) Hib (PRP-OMP)	ActHIB Hiberix PedvaxHIB
Hepatitis A vaccine	HepA	Havrix Vaqta
Hepatitis B vaccine	HepB	Engerix-B Recombivax HB
Human papillomavirus vaccine	HPV	Gardasil 9
Influenza vaccine (inactivated)	IIV	Multiple
Measles, mumps, and rubella vaccine	MMR	M-M-R II
Meningococcal serogroups A, C, W, Y vaccine	MenACWY-D MenACWY-CRM	Menactra Menveo
Meningococcal serogroup B vaccine	MenB-4C MenB-FHbp	Bexsero Trumenba
Pneumococcal 13-valent conjugate vaccine	PCV13	Prevnar 13
Pneumococcal 23-valent polysaccharide vaccine	PPSV23	Pneumovax
Poliovirus vaccine (inactivated)	IPV	IPOL
Rotavirus vaccines	RV1 RV5	Rotarix RotaTeq
Tetanus, diphtheria, and acellular pertussis vaccine	Tdap	Adacel Boostrix
Tetanus and diphtheria vaccine	Td	Tenivac No Trade Name
Varicella vaccine	VAR	Varivax
Combination Vaccines		
DTaP, hepatitis B and inactivated poliovirus vaccine	DTaP-HepB-IPV	Pediarix
DTaP, inactivated poliovirus and *Haemophilus influenzae* type B vaccine	DTaP-IPV/Hib	Pentacel
DTaP and inactivated poliovirus vaccine	DTaP-IPV	Kinrix Quadracel
Measles, mumps, rubella, and varicella vaccines	MMRV	ProQuad

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

Figure 1. Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger—United States, 2018.

(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 in gray.



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

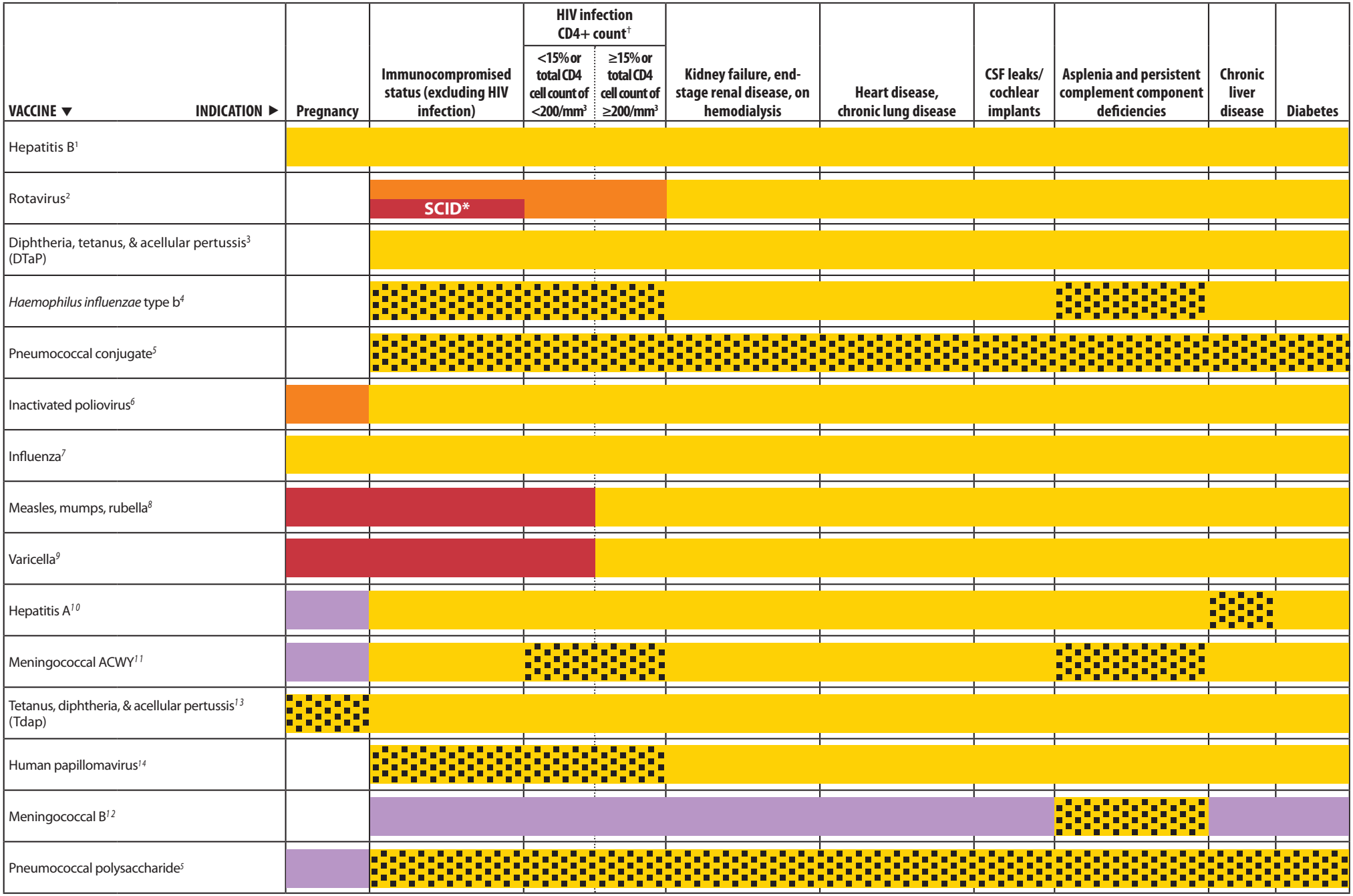
FIGURE 2. Catch-up immunization schedule for persons aged 4 months–18 years who start late or who are more than 1 month behind—United States, 2018.

The figure below provides catch-up schedules and minimum intervals between doses for children whose vaccinations have been delayed. A vaccine series does not need to be restarted, regardless of the time that has elapsed between doses. Use the section appropriate for the child's age. Always use this table in conjunction with Figure 1 and the footnotes that follow.

Vaccine	Minimum Age for Dose 1	Minimum Interval Between Doses			
		Dose 1 to Dose 2	Dose 2 to Dose 3	Dose 3 to Dose 4	Dose 4 to Dose 5
Children age 4 months through 6 years					
Hepatitis B[1]	Birth	4 weeks	8 weeks ***and*** at least 16 weeks after first dose. Minimum age for the final dose is 24 weeks.		
Rotavirus[2]	6 weeks Maximum age for first dose is 14 weeks, 6 days	4 weeks	4 weeks[2] Maximum age for final dose is 8 months, 0 days.		
Diphtheria, tetanus, and acellular pertussis[3]	6 weeks	4 weeks	4 weeks	6 months	6 months[3]
Haemophilus influenzae type b[4]	6 weeks	4 weeks if first dose was administered before the 1st birthday. 8 weeks (as final dose) if first dose was administered at age 12 through 14 months. No further doses needed if first dose was administered at age 15 months or older.	4 weeks[4] if current age is younger than 12 months **and** first dose was administered at younger than age 7 months, **and** at least 1 previous dose was PRP-T (ActHib, Pentacel, Hiberix) or unknown. 8 weeks ***and*** age 12 through 59 months (as final dose)[4] • if current age is younger than 12 months **and** first dose was administered at age 7 through 11 months; OR • if current age is 12 through 59 months **and** first dose was administered before the 1st birthday, **and** second dose administered at younger than 15 months; OR • if both doses were PRP-OMP (PedvaxHIB; Comvax) **and** were administered before the 1st birthday. No further doses needed if previous dose was administered at age 15 months or older.	8 weeks (as final dose) This dose only necessary for children age 12 through 59 months who received 3 doses before the 1st birthday.	
Pneumococcal conjugate[5]	6 weeks	4 weeks if first dose administered before the 1st birthday. 8 weeks (as final dose for healthy children) if first dose was administered at the 1st birthday or after. No further doses needed for healthy children if first dose was administered at age 24 months or older.	4 weeks if current age is younger than 12 months and previous dose given at <7 months old. 8 weeks (as final dose for healthy children) if previous dose given between 7-11 months (wait until at least 12 months old); OR if current age is 12 months or older and at least 1 dose was given before age 12 months. No further doses needed for healthy children if previous dose administered at age 24 months or older.	8 weeks (as final dose) This dose only necessary for children aged 12 through 59 months who received 3 doses before age 12 months or for children at high risk who received 3 doses at any age.	
Inactivated poliovirus[6]	6 weeks	4 weeks[6]	4 weeks[6] if current age is < 4 years 6 months (as final dose) if current age is 4 years or older	6 months[6] (minimum age 4 years for final dose).	
Measles, mumps, rubella[8]	12 months	4 weeks			
Varicella[9]	12 months	3 months			
Hepatitis A[10]	12 months	6 months			
Meningococcal[11] (MenACWY-D ≥9 mos; MenACWY-CRM ≥2 mos)	6 weeks	8 weeks[11]	See footnote 11	See footnote 11	
Children and adolescents age 7 through 18 years					
Meningococcal[11] (MenACWY-D ≥9 mos; MenACWY-CRM ≥2 mos)	Not Applicable (N/A)	8 weeks[11]			
Tetanus, diphtheria; tetanus, diphtheria, and acellular pertussis[13]	7 years[13]	4 weeks	4 weeks if first dose of DTaP/DT was administered before the 1st birthday. 6 months (as final dose) if first dose of DTaP/DT or Tdap/Td was administered at or after the 1st birthday.	6 months if first dose of DTaP/DT was administered before the 1st birthday.	
Human papillomavirus[14]	9 years	Routine dosing intervals are recommended.[14]			
Hepatitis A[10]	N/A	6 months			
Hepatitis B[1]	N/A	4 weeks	8 weeks **and** at least 16 weeks after first dose.		
Inactivated poliovirus[6]	N/A	4 weeks	6 months[6] A fourth dose is not necessary if the third dose was administered at age 4 years or older and at least 6 months after the previous dose.	A fourth dose of IPV is indicated if all previous doses were administered at <4 years or if the third dose was administered <6 months after the second dose.	
Measles, mumps, rubella[8]	N/A	4 weeks			
Varicella[9]	N/A	3 months if younger than age 13 years. 4 weeks if age 13 years or older.			

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

Figure 3. Vaccines that might be indicated for children and adolescents aged 18 years or younger based on medical indications



*Severe Combined Immunodeficiency

†For additional information regarding HIV laboratory parameters and use of live vaccines; see the General Best Practice Guidelines for Immunization "Altered Immunocompetence" at: www.cdc.gov/vaccines/hcp/acip-recs/general-recs/immunocompetence.html; and Table 4-1 (footnote D) at: www.cdc.gov/vaccines/hcp/acip-recs/general-recs/contraindications.html.

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

Footnotes — Recommended Immunization Schedule for Children and Adolescents Aged 18 Years or Younger, UNITED STATES, 2018

For further guidance on the use of the vaccines mentioned below, see: www.cdc.gov/vaccines/hcp/acip-recs/index.html.
For vaccine recommendations for persons 19 years of age and older, see the Adult Immunization Schedule.

Additional information

- For information on contraindications and precautions for the use of a vaccine, consult the *General Best Practice Guidelines for Immunization* and relevant ACIP statements, at www.cdc.gov/vaccines/hcp/acip-recs/index.html.
- For calculating intervals between doses, 4 weeks = 28 days. Intervals of ≥4 months are determined by calendar months.
- Within a number range (e.g., 12–18), a dash (–) should be read as "through."
- Vaccine doses administered ≤4 days before the minimum age or interval are considered valid. Doses of any vaccine administered ≥5 days earlier than the minimum interval or minimum age should not be counted as valid and should be repeated as age-appropriate. The repeat dose should be spaced after the invalid dose by the recommended minimum interval. For further details, see Table 3-1, *Recommended and minimum ages and intervals between vaccine doses,* in *General Best Practice Guidelines for Immunization* at www.cdc.gov/vaccines/hcp/acip-recs/general-recs/timing.html.
- Information on travel vaccine requirements and recommendations is available at wwwnc.cdc.gov/travel/.
- For vaccination of persons with immunodeficiencies, see Table 8-1, *Vaccination of persons with primary and secondary immunodeficiencies,* in *General Best Practice Guidelines for Immunization,* at www.cdc.gov/vaccines/hcp/acip-recs/general-recs/immunocompetence.html; and Immunization in Special Clinical Circumstances. (In: Kimberlin DW, Brady MT, Jackson MA, Long SS, eds. *Red Book: 2015 report of the Committee on Infectious Diseases. 30th ed.* Elk Grove Village, IL: American Academy of Pediatrics, 2015:68-107).
- The National Vaccine Injury Compensation Program (VICP) is a no-fault alternative to the traditional legal system for resolving vaccine injury claims. All routine child and adolescent vaccines are covered by VICP except for pneumococcal polysaccharide vaccine (PPSV23). For more information; see www.hrsa.gov/vaccinecompensation/index.html.

1. Hepatitis B (HepB) vaccine. (minimum age: birth)

Birth Dose (Monovalent HepB vaccine only):

- **Mother is HBsAg-Negative:** 1 dose within 24 hours of birth for medically stable infants ≥2,000 grams. Infants <2,000 grams administer 1 dose at chronological age 1 month or hospital discharge.
- **Mother is HBsAg-Positive:**
  - Give **HepB vaccine** and **0.5 mL of HBIG** (at separate anatomic sites) within 12 hours of birth, regardless of birth weight.
  - Test for HBsAg and anti-HBs at age 9–12 months. If HepB series is delayed, test 1–2 months after final dose.
- **Mother's HBsAg status is unknown:**
  - Give **HepB vaccine** within 12 hours of birth, regardless of birth weight.
  - For infants <2,000 grams, give **0.5 mL of HBIG** in addition to HepB vaccine within 12 hours of birth.
  - Determine mother's HBsAg status as soon as possible. If mother is HBsAg-positive, give **0.5 mL of HBIG** to infants ≥2,000 grams as soon as possible, but no later than 7 days of age.

Routine Series:

- A complete series is 3 doses at 0, 1–2, and 6–18 months. (Monovalent HepB vaccine should be used for doses given before age 6 weeks.)
- Infants who did not receive a birth dose should begin the series as soon as feasible (see Figure 2).
- Administration of **4 doses** is permitted when a combination vaccine containing HepB is used after the birth dose.
- **Minimum age** for the final (3rd or 4th) dose: 24 weeks.
- **Minimum Intervals:** Dose 1 to Dose 2: 4 weeks / Dose 2 to Dose 3: 8 weeks / Dose 1 to Dose 3: 16 weeks. (When 4 doses are given, substitute "Dose 4" for "Dose 3" in these calculations.)

Catch-up vaccination:

- Unvaccinated persons should complete a 3-dose series at 0, 1–2, and 6 months.
- Adolescents 11–15 years of age may use an alternative 2-dose schedule, with at least 4 months between doses (adult formulation **Recombivax HB** only).
- For other catch-up guidance, see Figure 2.

2. Rotavirus vaccines. (minimum age: 6 weeks)

Routine vaccination:

Rotarix: 2-dose series at 2 and 4 months.

RotaTeq: 3-dose series at 2, 4, and 6 months.

If any dose in the series is either RotaTeq or unknown, default to 3-dose series.

Catch-up vaccination:

- Do not start the series on or after age 15 weeks, 0 days.
- The maximum age for the final dose is 8 months, 0 days.
- For other catch-up guidance, see Figure 2.

3. Diphtheria, tetanus, and acellular pertussis (DTaP) vaccine. (minimum age: 6 weeks [4 years for Kinrix or Quadracel])

Routine vaccination:

- 5-dose series at 2, 4, 6, and 15–18 months, and 4–6 years.
  - **Prospectively:** A 4th dose may be given as early as age 12 months if at least 6 months have elapsed since the 3rd dose.
  - **Retrospectively:** A 4th dose that was inadvertently given as early as 12 months may be counted if at least 4 months have elapsed since the 3rd dose.

Catch-up vaccination:

- The 5th dose is not necessary if the 4th dose was administered at 4 years or older.
- For other catch-up guidance, see Figure 2.

For further guidance on the use of the vaccines mentioned below, see: www.cdc.gov/vaccines/hcp/acip-recs/index.html.

4. *Haemophilus influenzae* type b (Hib) vaccine. (minimum age: 6 weeks)

Routine vaccination:

- **ActHIB, Hiberix, or Pentacel:** 4-dose series at 2, 4, 6, and 12–15 months.
- **PedvaxHIB:** 3-dose series at 2, 4, and 12–15 months.

Catch-up vaccination:

- **1st dose at 7–11 months:** Give 2nd dose at least 4 weeks later and 3rd (final) dose at 12–15 months or 8 weeks after 2nd dose (whichever is later).
- **1st dose at 12–14 months:** Give 2nd (final) dose at least 8 weeks after 1st dose.
- **1st dose before 12 months and 2nd dose before 15 months:** Give 3rd (final) dose 8 weeks after 2nd dose.
- **2 doses of PedvaxHIB before 12 months:** Give 3rd (final) dose at 12–59 months and at least 8 weeks after 2nd dose.
- **Unvaccinated at 15–59 months:** 1 dose.
- For other catch-up guidance, see Figure 2.

Special Situations:

- **Chemotherapy or radiation treatment**
  12–59 months
  - Unvaccinated or only 1 dose before 12 months: Give 2 doses, 8 weeks apart
  - 2 or more doses before 12 months: Give 1 dose, at least 8 weeks after previous dose.

  Doses given within 14 days of starting therapy or during therapy should be repeated at least 3 months after therapy completion.
- **Hematopoietic stem cell transplant (HSCT)**
- 3-dose series with doses 4 weeks apart starting 6 to 12 months after successful transplant (regardless of Hib vaccination history).
- **Anatomic or functional asplenia (including sickle cell disease)**
  12–59 months
  - Unvaccinated or only 1 dose before 12 months: Give 2 doses, 8 weeks apart.
  - 2 or more doses before 12 months: Give 1 dose, at least 8 weeks after previous dose.

  Unimmunized persons 5 years or older*
  - Give 1 dose
- **Elective splenectomy**
  Unimmunized* persons 15 months or older
  - Give 1 dose (preferably at least 14 days before procedure).
- **HIV infection**
  12–59 months
  - Unvaccinated or only 1 dose before 12 months: Give 2 doses 8 weeks apart.
  - 2 or more doses before 12 months: Give 1 dose, at least 8 weeks after previous dose.

  Unimmunized persons 5–18 years*
  - Give 1 dose
- **Immunoglobulin deficiency, early component complement deficiency**
  12–59 months
  - Unvaccinated or only 1 dose before 12 months: Give 2 doses, 8 weeks apart.
  - 2 or more doses before 12 months: Give 1 dose, at least 8 weeks after previous dose.

**Unimmunized* = Less than routine series (through 14 months) OR no doses (14 months or older)

5. Pneumococcal vaccines. (minimum age: 6 weeks [PCV13], 2 years [PPSV23])

Routine vaccination with PCV13:

- 4-dose series at 2, 4, 6, and 12–15 months.

Catch-up vaccination with PCV13:

- 1 dose for healthy children aged 24–59 months with any incomplete* PCV13 schedule
- For other catch-up guidance, see Figure 2.

Special situations: High-risk conditions: Administer PCV13 doses before PPSV23 if possible.

Chronic heart disease (particularly cyanotic congenital heart disease and cardiac failure); chronic lung disease (including asthma treated with high-dose, oral, corticosteroids); diabetes mellitus:

Age 2–5 years:

- Any incomplete* schedules with:
  - 3 PCV13 doses: 1 dose of PCV13 (at least 8 weeks after any prior PCV13 dose).
  - <3 PCV13 doses: 2 doses of PCV13, 8 weeks after the most recent dose and given 8 weeks apart.
- No history of PPSV23: 1 dose of PPSV23 (at least 8 weeks after any prior PCV13 dose).

Age 6-18 years:

- No history of PPSV23: 1 dose of PPSV23 (at least 8 weeks after any prior PCV13 dose).

Cerebrospinal fluid leak; cochlear implant:

Age 2–5 years:

- Any incomplete* schedules with:
  - 3 PCV13 doses: 1 dose of PCV13 (at least 8 weeks after any prior PCV13 dose).
  - <3 PCV13 doses: 2 doses of PCV13, 8 weeks after the most recent dose and given 8 weeks apart.
- No history of PPSV23: 1 dose of PPSV23 (at least 8 weeks after any prior PCV13 dose).

Age 6–18 years:

- No history of either PCV13 or PPSV23: 1 dose of PCV13, 1 dose of PPSV23 at least 8 weeks later.
- Any PCV13 but no PPSV23: 1 dose of PPSV23 at least 8 weeks after the most recent dose of PCV13
- PPSV23 but no PCV13: 1 dose of PCV13 at least 8 weeks after the most recent dose of PPSV23.

Sickle cell disease and other hemoglobinopathies; anatomic or functional asplenia; congenital or acquired immunodeficiency; HIV infection; chronic renal failure; nephrotic syndrome; malignant neoplasms, leukemias, lymphomas, Hodgkin disease, and other diseases associated with treatment with immunosuppressive drugs or radiation therapy; solid organ transplantation; multiple myeloma:

Age 2–5 years:

- Any incomplete* schedules with:
  - 3 PCV13 doses: 1 dose of PCV13 (at least 8 weeks after any prior PCV13 dose).
  - <3 PCV13 doses: 2 doses of PCV13, 8 weeks after the most recent dose and given 8 weeks apart.
- No history of PPSV23: 1 dose of PPSV23 (at least 8 weeks after any prior PCV13 dose) and a 2nd dose of PPSV23 5 years later.

Age 6–18 years:

- No history of either PCV13 or PPSV23: 1 dose of PCV13, 2 doses of PPSV23 (1st dose of PPSV23 administered 8 weeks after PCV13 and 2nd dose of PPSV23 administered at least 5 years after the 1st dose of PPSV23).
- Any PCV13 but no PPSV23: 2 doses of PPSV23 (1st dose of PPSV23 to be given 8 weeks after the most recent dose of PCV13 and 2nd dose of PPSV23 administered at least 5 years after the 1st dose of PPSV23).

For further guidance on the use of the vaccines mentioned below, see: www.cdc.gov/vaccines/hcp/acip-recs/index.html.

- PPSV23 but no PCV13: 1 dose of PCV13 at least 8 weeks after the most recent PPSV23 dose and a 2nd dose of PPSV23 to be given 5 years after the 1st dose of PPSV23 and at least 8 weeks after a dose of PCV13.

Chronic liver disease, alcoholism:

Age 6–18 years:

- No history of PPSV23: 1 dose of PPSV23 (at least 8 weeks after any prior PCV13 dose).

*Incomplete schedules are any schedules where PCV13 doses have not been completed according to ACIP recommended catch-up schedules. The total number and timing of doses for complete PCV13 series are dictated by the age at first vaccination. See Tables 8 and 9 in the ACIP pneumococcal vaccine recommendations (www.cdc.gov/mmwr/pdf/rr/rr5911.pdf) for complete schedule details.

6. Inactivated poliovirus vaccine (IPV). (minimum age: 6 weeks)

Routine vaccination:

- 4-dose series at ages 2, 4, 6–18 months, and 4–6 years. Administer the final dose on or after the 4th birthday and at least 6 months after the previous dose.

Catch-up vaccination:

- In the first 6 months of life, use minimum ages and intervals only for travel to a polio-endemic region or during an outbreak.
- If 4 or more doses were given before the 4th birthday, give 1 more dose at age 4–6 years and at least 6 months after the previous dose.
- A 4th dose is not necessary if the 3rd dose was given on or after the 4th birthday and at least 6 months after the previous dose.
- IPV is not routinely recommended for U.S. residents 18 years and older.

Series Containing Oral Polio Vaccine (OPV), *either mixed OPV-IPV or OPV-only series*:

- Total number of doses needed to complete the series is the same as that recommended for the U.S. IPV schedule. See www.cdc.gov/mmwr/volumes/66/wr/mm6601a6.htm?s_cid=mm6601a6_w.
- Only trivalent OPV (tOPV) counts toward the U.S. vaccination requirements. For guidance to assess doses documented as "OPV" see www.cdc.gov/mmwr/volumes/66/wr/mm6606a7.htm?s_cid=mm6606a7_w.
- For other catch-up guidance, see Figure 2.

7. Influenza vaccines. (minimum age: 6 months)

Routine vaccination:

- Administer an age-appropriate formulation and dose of influenza vaccine annually.
  - o **Children 6 months–8 years** who did not receive at least 2 doses of influenza vaccine before July 1, 2017 should receive 2 doses separated by at least 4 weeks.
  - o **Persons 9 years and older** 1 dose
- Live attenuated influenza vaccine (LAIV) not recommended for the 2017–18 season.
- For additional guidance, see the 2017–18 ACIP influenza vaccine recommendations (*MMWR* August 25, 2017;66(2):1-20: www.cdc.gov/mmwr/volumes/66/rr/pdfs/rr6602.pdf).

(For the 2018–19 season, see the 2018–19 ACIP influenza vaccine recommendations.)

8. Measles, mumps, and rubella (MMR) vaccine. (minimum age: 12 months for routine vaccination)

Routine vaccination:

- 2-dose series at 12–15 months and 4–6 years.
- The 2nd dose may be given as early as 4 weeks after the 1st dose.

Catch-up vaccination:

- Unvaccinated children and adolescents: 2 doses at least 4 weeks apart.

International travel:

- **Infants 6–11 months:** 1 dose before departure. Revaccinate with 2 doses at 12–15 months (12 months for children in high-risk areas) and 2nd dose as early as 4 weeks later.
- **Unvaccinated children 12 months and older:** 2 doses at least 4 weeks apart before departure.

Mumps outbreak:

- Persons ≥12 months who previously received ≤2 doses of mumps-containing vaccine and are identified by public health authorities to be at increased risk during a mumps outbreak should receive a dose of mumps-virus containing vaccine.

9. Varicella (VAR) vaccine. (minimum age: 12 months)

Routine vaccination:

- 2-dose series: 12–15 months and 4–6 years.
- The 2nd dose may be given as early as 3 months after the 1st dose (a dose given after a 4-week interval may be counted).

Catch-up vaccination:

- Ensure persons 7–18 years without evidence of immunity (see *MMWR* 2007;56[No. RR-4], at www.cdc.gov/mmwr/pdf/rr/rr5604.pdf) have 2 doses of varicella vaccine:
  - o **Ages 7–12:** routine interval 3 months (minimum interval: 4 weeks).
  - o **Ages 13 and older:** minimum interval 4 weeks.

10. Hepatitis A (HepA) vaccine. (minimum age: 12 months)

Routine vaccination:

- 2 doses, separated by 6-18 months, between the 1st and 2nd birthdays. (A series begun before the 2nd birthday should be completed even if the child turns 2 before the second dose is given.)

Catch-up vaccination:

- Anyone 2 years of age or older may receive HepA vaccine if desired. Minimum interval between doses is 6 months.

Special populations:

Previously unvaccinated persons who should be vaccinated:

- Persons traveling to or working in countries with high or intermediate endemicity
- Men who have sex with men
- Users of injection and non-injection drugs
- Persons who work with hepatitis A virus in a research laboratory or with non-human primates
- Persons with clotting-factor disorders
- Persons with chronic liver disease
- Persons who anticipate close, personal contact (e.g., household or regular babysitting) with an international adoptee during the first 60 days after arrival in the United States from a country with high or intermediate endemicity (administer the 1st dose as soon as the adoption is planned—ideally at least 2 weeks before the adoptee's arrival).

11. Serogroup A, C, W, Y meningococcal vaccines. (Minimum age: 2 months [Menveo], 9 months [Menactra].

Routine:

- 2-dose series: 11-12 years and 16 years.

Catch-Up:

- Age 13-15 years: 1 dose now and booster at age 16-18 years. Minimum interval 8 weeks.
- Age 16-18 years: 1 dose.

For further guidance on the use of the vaccines mentioned below, see: www.cdc.gov/vaccines/hcp/acip-recs/index.html.

Special populations and situations:
Anatomic or functional asplenia, sickle cell disease, HIV infection, persistent complement component deficiency (including eculizumab use):

- **Menveo**
  - 1st dose at 8 weeks: 4-dose series at 2, 4, 6, and 12 months.
  - 1st dose at 7–23 months: 2 doses (2nd dose at least 12 weeks after the 1st dose and after the 1st birthday).
  - 1st dose at 24 months or older: 2 doses at least 8 weeks apart.
- **Menactra**
  - Persistent complement component deficiency:
    - 9–23 months: 2 doses at least 12 weeks apart
    - 24 months or older: 2 doses at least 8 weeks apart
  - Anatomic or functional asplenia, sickle cell disease, or HIV infection:
    - 24 months or older: 2 doses at least 8 weeks apart.
    - **Menactra** must be administered at least 4 weeks after completion of PCV13 series.

Children who travel to or live in countries where meningococcal disease is hyperendemic or epidemic, including countries in the African meningitis belt or during the Hajj, or exposure to an outbreak attributable to a vaccine serogroup:

- Children <24 months of age:
  - **Menveo (2-23 months):**
    - 1st dose at 8 weeks: 4-dose series at 2, 4, 6, and 12 months.
    - 1st dose at 7-23 months: 2 doses (2nd dose at least 12 weeks after the 1st dose and after the 1st birthday).
  - **Menactra (9-23 months):**
    - 2 doses (2nd dose at least 12 weeks after the 1st dose. 2nd dose may be administered as early as 8 weeks after the 1st dose in travelers).
- Children 2 years or older: 1 dose of **Menveo** or **Menactra**.

Note: Menactra should be given either before or at the same time as DTaP. For MenACWY booster dose recommendations for groups listed under "Special populations and situations" above, and additional meningococcal vaccination information, see meningococcal *MMWR* publications at: www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/mening.html.

12. Serogroup B meningococcal vaccines (minimum age: 10 years [Bexsero, Trumenba].

Clinical discretion: Adolescents not at increased risk for meningococcal B infection who want MenB vaccine.

MenB vaccines may be given at clinical discretion to adolescents 16–23 years (preferred age 16–18 years) who are not at increased risk.

- **Bexsero**: 2 doses at least 1 month apart.
- **Trumenba**: 2 doses at least 6 months apart. If the 2nd dose is given earlier than 6 months, give a 3rd dose at least 4 months after the 2nd.

Special populations and situations:
Anatomic or functional asplenia, sickle cell disease, persistent complement component deficiency (including eculizumab use), serogroup B meningococcal disease outbreak

- **Bexsero**: 2-dose series at least 1 month apart.
- **Trumenba**: 3-dose series at 0, 1-2, and 6 months.

Note: **Bexsero** and **Trumenba** are not interchangeable.
For additional meningococcal vaccination information, see meningococcal *MMWR* publications at: www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/mening.html.

13. Tetanus, diphtheria, and acellular pertussis (Tdap) vaccine. (minimum age: 11 years for routine vaccinations, 7 years for catch-up vaccination)

Routine vaccination:

- **Adolescents 11–12 years of age:** 1 dose.
- **Pregnant adolescents:** 1 dose during each pregnancy (preferably during the early part of gestational weeks 27–36).
- Tdap may be administered regardless of the interval since the last tetanus- and diphtheria-toxoid-containing vaccine.

Catch-up vaccination:

- **Adolescents 13–18 who have not received Tdap**: 1 dose, followed by a Td booster every 10 years.
- **Persons aged 7–18 years not fully immunized with DTaP**: 1 dose of Tdap as part of the catch-up series (preferably the first dose). If additional doses are needed, use Td.
- **Children 7–10 years** who receive Tdap inadvertently or as part of the catch-up series may receive the routine Tdap dose at 11–12 years.
- **DTaP inadvertently given after the 7th birthday**:
  - **Child 7–10**: DTaP may count as part of catch-up series. Routine Tdap dose at 11-12 may be given.
  - **Adolescent 11–18**: Count dose of DTaP as the adolescent Tdap booster.
- For other catch-up guidance, see Figure 2.

14. Human papillomavirus (HPV) vaccine (minimum age: 9 years)

Routine and catch-up vaccination:

- Routine vaccination for all adolescents at 11–12 years (can start at age 9) and through age 18 if not previously adequately vaccinated. Number of doses dependent on age at initial vaccination:
  - **Age 9–14 years at initiation:** 2-dose series at 0 and 6–12 months. Minimum interval: 5 months (repeat a dose given too soon at least 12 weeks after the invalid dose and at least 5 months after the 1st dose).
  - **Age 15 years or older at initiation:** 3-dose series at 0, 1–2 months, and 6 months. Minimum intervals: 4 weeks between 1st and 2nd dose; 12 weeks between 2nd and 3rd dose; 5 months between 1st and 3rd dose (repeat dose(s) given too soon at or after the minimum interval since the most recent dose).
- Persons who have completed a valid series with any HPV vaccine do not need any additional doses.

Special situations:

- **History of sexual abuse or assault**: Begin series at age 9 years.
- **Immunocompromised* (including HIV)** aged 9–26 years: 3-dose series at 0, 1–2 months, and 6 months.
- **Pregnancy:** Vaccination not recommended, but there is no evidence the vaccine is harmful. No intervention is needed for women who inadvertently received a dose of HPV vaccine while pregnant. Delay remaining doses until after pregnancy. Pregnancy testing not needed before vaccination.

*See MMWR, December 16, 2016;65(49):1405–1408, at www.cdc.gov/mmwr/volumes/65/wr/pdfs/mm6549a5.pdf.

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2018 immunization schedules released

The 2018 recommended childhood and adolescent immunization schedules released today include several updates and modifications to the catch-up schedule and the schedule for people ages 0 through 18 years who have a specific medical indication.

In addition, some footnotes have been revised, and a table has been added to the title page showing the common abbreviations and brand names for vaccines recommended for children and adolescents.

No changes have been made to the schedule for children and adolescents 18 or younger.

The schedules are revised and approved annually by the Academy, the Advisory Committee on Immunization Practices of the Centers for Disease Control and Prevention (CDC), the American Academy of Family Physicians and the American College of Obstetricians and Gynecologists to reflect current recommendations for the use of vaccines licensed by the Food and Drug Administration.

Two changes have been made to the catch-up immunization schedule for people ages 4 months to 18 years who start late or are more than one month behind:

- The rotavirus vaccine now includes the maximum ages for the first and last doses of the series.
- The polio vaccine rows clarify the catch-up schedule for people ages 4 and older.

Additionally, the schedule of vaccines that may be indicated for children and adolescents ages 18 years or younger based on medical indications now includes a reference for use of live vaccines in people with HIV.

Tables clarify the recommended use of *Haemophilus influenzae* type b, pneumococcal and pertussis-containing vaccines as a function of age, number of doses previously administered and the time interval since the last dose.

Footnote updates

Changes have been made to the following footnotes:

- **Hepatitis B.** Information has been added regarding the timing of the birth dose for infants with a birth weight of less than 2,000 grams who are born to HBsAg-negative mothers.
- ***Haemophilus influenzae* type b.** MenHibrix (Hib-MenCY) has been removed because the vaccine is no longer commercially available, and all remaining doses have expired.
- **Influenza.** Wording has been changed to indicate that live attenuated influenza vaccine is not recommended for the 2017-'18 influenza season.
- **Meningococcal vaccines.** Only MenACWY vaccines are discussed in footnote #11. MenB vaccines are discussed in footnote #12.
- **Polio vaccines.** Updated wording provides guidance for children who have received oral polio vaccine as part of their series.
- **Measles-mumps-rubella vaccines.** Guidance is provided on use of a third dose of a mumps-containing vaccine during a mumps outbreak.

Clinically significant adverse events that follow immunization should be reported to the Vaccine Adverse Event Reporting System (VAERS). Guidance on how to obtain and complete a VAERS form can be found at

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www.vaers.hhs.gov or by calling 800-822-7967.

Resources

- The 2018 immunization schedules are available at Red Book Online, https://redbook.solutions.aap.org/SS/Immunization_Schedules.aspx, and the CDC website, www.cdc.gov/vaccines/schedules/hcp/child-adolescent.html
- Parent-friendly vaccine schedule for children and adolescents from HealthyChildren.org
- A collection of immunization articles from AAP periodicals and journals
- Additional information can be found in the AAP Red Book and Red Book Online

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AAP influenza immunization recommendations revised for 2018-'19 season

by Flor M. Munoz-Rivas M.D., FAAP; Henry H. Bernstein D.O., M.H.C.M., FAAP

Annual seasonal influenza vaccination is recommended for everyone 6 months and older, as vaccination remains the best available preventive measure. Achieving high coverage rates of influenza vaccine in infants and children is a priority to protect them against influenza disease and its complications.

There are new recommendations for the upcoming 2018-'19 influenza season. Unlike the last two seasons, the Academy recommends the limited use of intranasal live attenuated influenza vaccine (LAIV4), as explained below. This recommendation represents a change from the 2016-'17 and 2017-'18 influenza seasons when intranasal LAIV4 was not recommended in any setting in light of the evidence for its poor effectiveness in prior seasons against influenza A (H1N1) pdm09 viruses.

The AAP Committee on Infectious Diseases (COID) and the Advisory Committee on Immunization Practices (ACIP) of the Centers for Disease Control and Prevention (CDC) have reviewed and carefully considered all influenza vaccine efficacy data available to date, as well as new information regarding an updated LAIV4 formulation, for each to provide their latest recommendations.

ACIP voted to recommend LAIV4 as an option for anyone in whom it is otherwise appropriate and stated that no vaccine effectiveness estimates are available for the new formulation of LAIV4.

While the AAP and CDC each support the use of LAIV4 for the 2018-'19 influenza season with the aim of achieving adequate vaccination coverage and optimal protection in children of all ages, the AAP is making the following recommendations:

- Annual influenza vaccination is recommended for everyone 6 months and older.
- For the 2018-'19 season, the AAP recommends inactivated influenza vaccine (IIV3/4) as the primary choice for all children because the effectiveness of LAIV4:

1. was inferior against A/H1N1 during past seasons; and
2. is unknown against A/H1N1 for this upcoming season.

- LAIV4 may be offered for children who would not otherwise receive an influenza vaccine (and for whom it is appropriate by age and health status).
- As always, families should receive counseling on these revised recommendations for the 2018-'19 season.

A summary of the scientific data reviewed by COID that led to the Academy's recommendation for the limited use of LAIV4 in the 2018-'19 season follows:

1. The CDC conducted a systematic review of all published studies evaluating the effectiveness of LAIV3 and LAIV4 in children from the 2010-'11 to the 2016-'17 seasons, including data from U.S. and European studies. The data suggested that the effectiveness of LAIV3 or LAIV4 for influenza strain A/H1N1 was lower than IIV in children 2 to 17 years old. However, LAIV was more effective against influenza B strains and similarly effective against A/H3N2 when compared with IIV.
2. Preliminary influenza vaccine effectiveness data for the A/H3N2 predominant, moderately severe 2017-'18

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season have revealed that IIV provided adequate protection against A/H1N1 and B influenza viruses and low but measurable protection against A/H3N2 viruses and varied by age group.

3. The manufacturer of LAIV4 explored the process of viral strain selection for its vaccine, evaluating the viral shedding and immune responses in U.S. children 2 to less than 4 years of age after receipt of a new formulation of LAIV4 that utilized a different A/H1N1 strain (A/Slovenia/2903/2015). The manufacturer's study data suggest that the new A (H1N1) pdm09-like virus (A/Slovenia/2903/2015) has improved replicative fitness over previous LAIV4 A (H1N1) pdm09-like vaccine strains and leads to immune responses in toddlers. There are no published effectiveness estimates for this vaccine strain formulation against influenza A (H1N1) pdm09 viruses because influenza A (H3N2) and influenza B viruses have predominated during the latest season. The effectiveness of this new formulation of LAIV4 has not been confirmed, since A/H1N1 virus has not widely circulated recently. Neither nasal shedding of vaccine virus nor immunogenicity has been shown to correlate with effectiveness of LAIV.

Based on currently available data, the AAP recommends the administration of IIV for all children and adolescents, particularly those with underlying medical conditions associated with an elevated risk of complications from influenza. Detailed recommendations will be provided in the AAP 2018-'19 influenza policy statement that will be released online in early September.

The CDC also will publish additional information in its *Morbidity and Mortality Weekly Report* (*MMWR)* and will analyze post-marketing safety and real-time vaccine effectiveness data as they become available during the 2018-'19 influenza season.

*Dr. Munoz-Rivas is a member of the AAP Committee on Infectious Diseases (COID). Dr. Bernstein is a member of the Advisory Committee on Immunization Practices, associate editor of*Red Book *Online and an ex officio member of COID.*

Immunization Case Scenarios

Case I

You are seeing 3 yo Kirsten for a well child visit. She has never received any vaccines. What vaccine would you prescribe today?

When would you schedule the next visit? What would you prescribe at that visit?

Case II

You are seeing 4 yo DeAndre who has sickle cell anemia. He has received DTaP x 4, IPV x 3, MMR, Varivax, and Hib x 3. What vaccines would you prescribe today?

Case III

You are seeing 17 yo Cory for a college physical. He has received DTaP x 5, IPV x 4, MMR x 2, Hib x 2. What vaccines would you prescribe?

Case IV

You are seeing 22 mo Molly who was adopted from China. Her translated immunization booklet indicates that she received DTap x 3, IPV x 3, Hib x 3, HepB x 3, MMR x 1, **BCG x 1**, and varivax x 1. What would you prescribe today?

Board Review Questions:

1. A family comes to your office for consultation regarding a 3-week trip to India they are planning to take in 3 months. The children, a 9-year-old boy and a 7-month-old girl, are well, and their immunizations are up to date.

Of the following, the MOST appropriate prophylaxis to provide in preparation for travel is :

A. chloroquine for both children
B. hepatitis A vaccination for both children
C. measles vaccination for the girl
D. polio vaccination for the boy
E. typhoid vaccine for both children

2. A 14-year-old girl presents to your emergency department for evaluation of a 3-week history of progressive episodes of coughing spasms. She reports several episodes of post-tussive vomiting and difficulty sleeping at night. She denies night sweats or weight loss and says she was previously well. She does not take any medications.

Of the following, the MOST important additional information to obtain is a history of:

A. gastroesophageal reflux disease
B. international travel over the past year
C. pet or animal exposures
D. spelunking trips in the last 6 months
E. vaccinations received since 11 years of age

3. A 6-month-old boy presents to the emergency department with a 2-day history of fever and a 1-day history of left cheek swelling. You discover that his parents do not believe in providing their children with immunizations. Despite this, the boy has never been ill. He has two older siblings, and nobody is sick at home. The mother denies any recent bug bites or trauma to the area on his cheek. Physical examination reveals a mildly toxic-appearing child who has a temperature of 103.0°F (39.4°C), heart rate of 145 beats/min, respiratory rate of 26 breaths/min, and blood pressure of 80/45 mm Hg. His anterior fontanelle is slightly bulging, his tympanic membranes are erythematous, his left cheek is indurated and appears erythematous to slightly violaceous, and he is irritable.

Of the following, the MOST likely organism to cause this child's illness is:

A. Haemophilus influenzae type b
B. Neisseria meningitidis
C. Staphylococcus aureus
D. Streptococcus pneumoniae
E. Streptococcus pyogenes

4. A mother calls you to report that her 7-year-old son came home with a notice from school stating that a child in his class was diagnosed with mumps. The mother does not know the immunization status of the infected child but states that her son has received two measles-mumps-rubella (MMR) vaccines and is up to date on all his other immunizations. Her son has been asymptomatic, with no fever or other systemic complaints.

Of the following, the MOST appropriate action is to:

A. administer a dose of mumps immune globulin to her son
B. confirm that her son has received two doses of MMR vaccine
C. keep her son home from school for 9 days to observe for the development of symptoms
D. treat her son with a course of ribavirin
E. vaccinate her son immediately with another dose of MMR to prevent infection from this exposure

5. You are hiring a pediatrician as a hospitalist at a community hospital.

Of the following, the disease for which immune status MUST be documented at the time of employment is:

A. diphtheria
B. hepatitis A
C. measles
D. meningococcal disease
E. tetanus