NCC Pediatrics Continuity Clinic Curriculum:
Immunizations
Faculty Guide

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"
  - 2017 Combined Immunization Schedule (0-18 yrs)
  - 2017 Immunization Updates (from AAP News)
  - 2017-2018 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**
- Understanding vaccine precautions, contraindications
- 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, 2017

This schedule includes recommendations in effect as of January 1, 2017. 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 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 (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 (www.cdc.gov/vaccines/hcp/admin/contraindications.html) or by telephone (800-CDC-INFO [800-232-4636]).

The Recommended Immunization Schedule for
Children and Adolescents Aged 18 Years or Younger are 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)

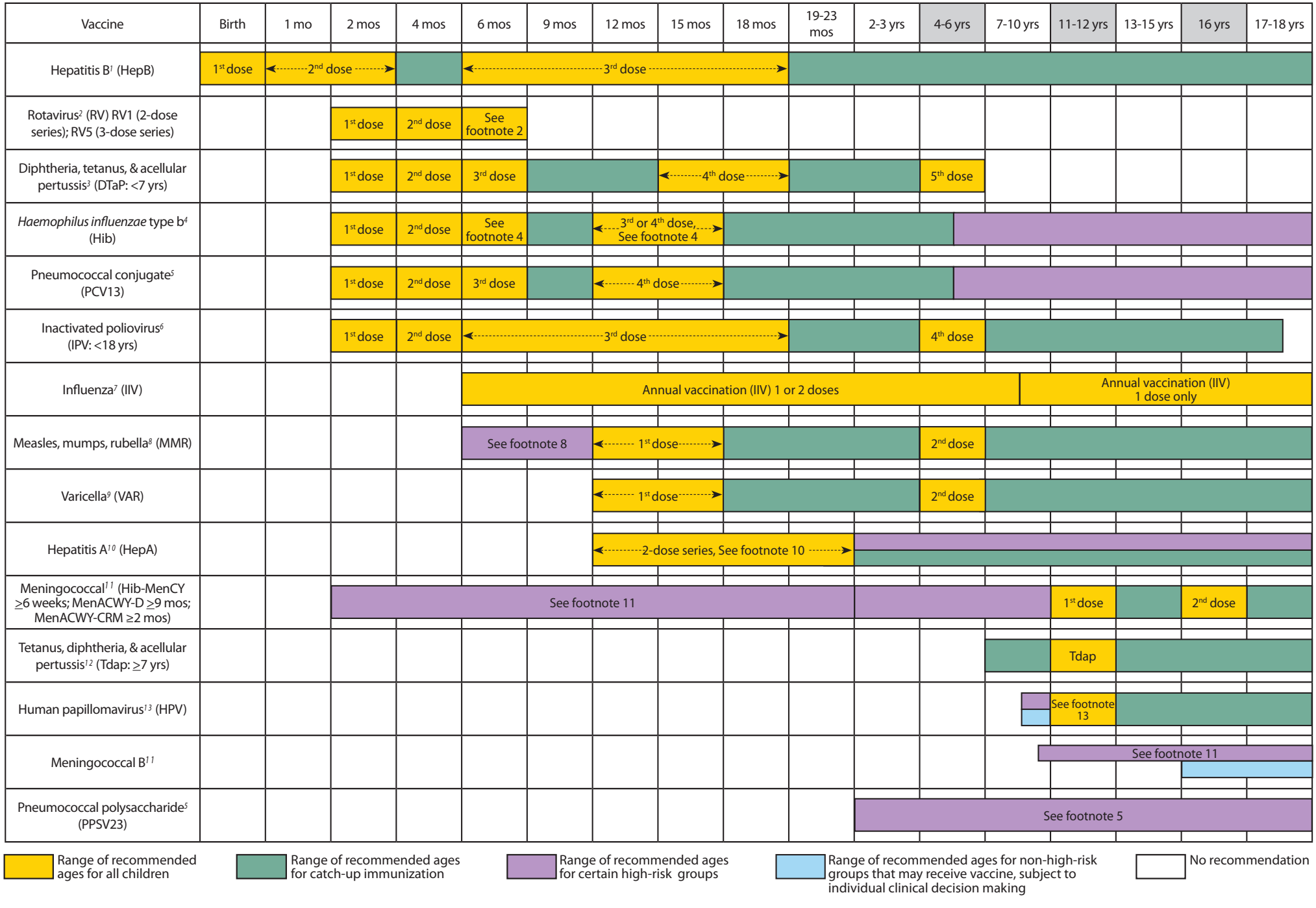
American College of Obstetricians and Gynecologists
(www.acog.org)

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, 2017.

(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.

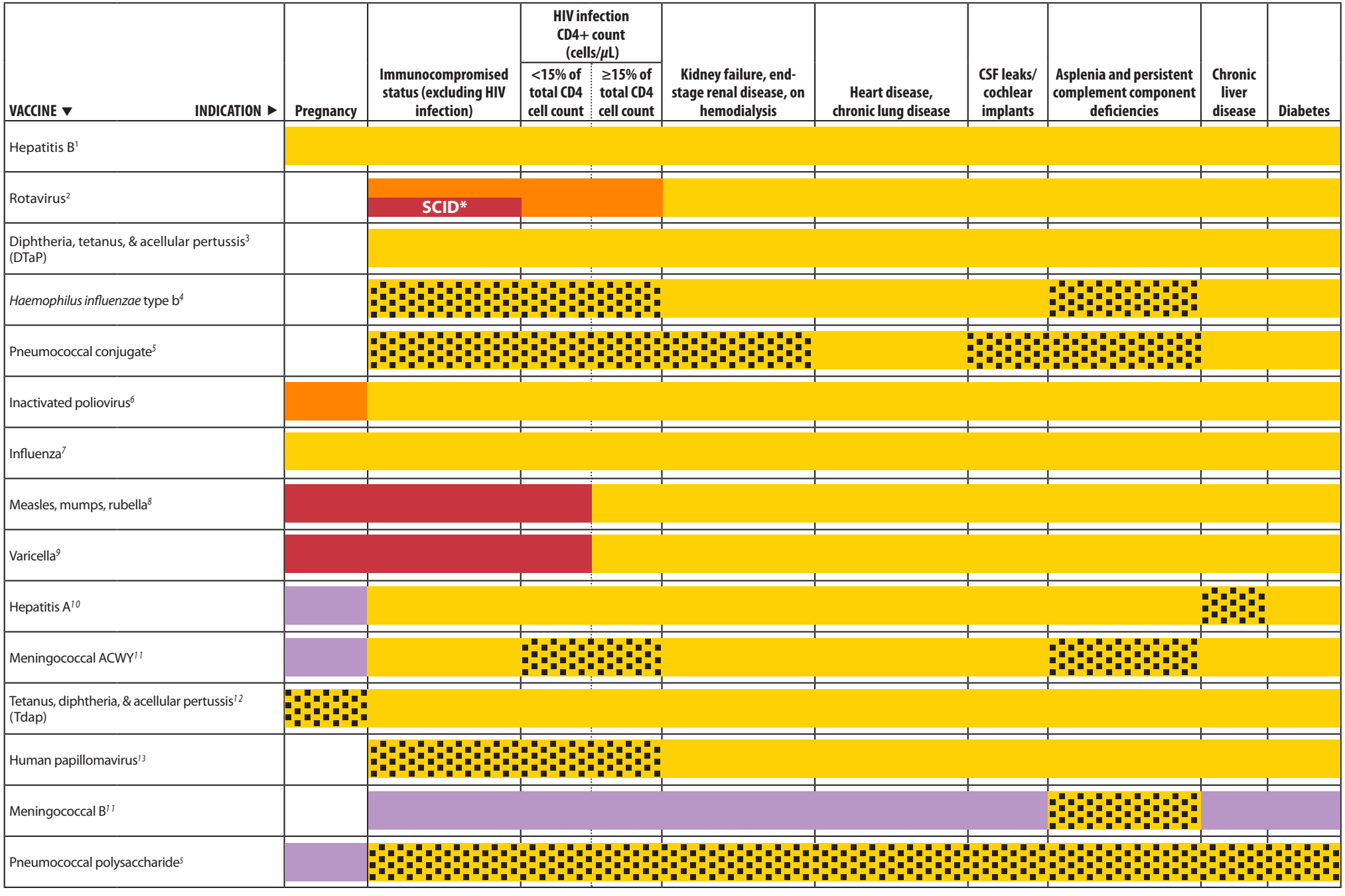
FIGURE 2. Catch-up immunization schedule for persons aged 4 months through 18 years who start late or who are more than 1 month behind—United States, 2017.

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.

Children age 4 months through 6 years					
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
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	4 weeks	4 weeks[2]		
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[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]	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] (Hib-MenCY ≥6 weeks; 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[12]	7 years[12]	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[13]	9 years	Routine dosing intervals are recommended.[13]			
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	4 weeks[6]	6 months[6]	
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

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, 2017

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 and for additional information regarding that vaccine, vaccination providers should consult the ACIP General Recommendations on Immunization and the relevant ACIP statement, available online at www.cdc.gov/vaccines/hcp/acip-recs/index.html.
- For purposes of calculating intervals between doses, 4 weeks = 28 days. Intervals of 4 months or greater are determined by calendar months.
- Vaccine doses administered ≤4 days before the minimum 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 doses 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 1, *Recommended and minimum ages and intervals between vaccine doses, in MMWR, General Recommendations on Immunization and Reports / Vol. 60 / No. 2,* available online at www.cdc.gov/mmwr/pdf/rr/rr6002.pdf.
- Information on travel vaccine requirements and recommendations is available at wwwnc.cdc.gov/travel/.
- For vaccination of persons with primary and secondary immunodeficiencies, see Table 13, *Vaccination of persons with primary and secondary immunodeficiencies,* in *General Recommendations on Immunization* (ACIP), available at www.cdc.gov/mmwr/pdf/rr/rr6002.pdf.; and Immunization in Special Clinical Circumstances, (American Academy of Pedatrics). 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 petitions. Created by the National Childhood Vaccine Injury Act of 1986, it provides compensation to people found to be injured by certain vaccines. All vaccines within the recommended childhood immunization schedule 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)**
Routine vaccination:
At birth:
   - Administer monovalent HepB vaccine to all newborns within 24 hours of birth.
   - For infants born to hepatitis B surface antigen (HBsAg)-positive mothers, administer HepB vaccine and 0.5 mL of hepatitis B immune globulin (HBIG) within 12 hours of birth. These infants should be tested for HBsAg and antibody to HBsAg (anti-HBs) at age 9 through 12 months (preferably at the next well-child visit) or 1 to 2 months after completion of the HepB series if the series was delayed.
   - If mother's HBsAg status is unknown, within 12 hours of birth, administer HepB vaccine regardless of birth weight. For infants weighing less than 2,000 grams, administer HBIG in addition to HepB vaccine within 12 hours of birth. Determine mother's HBsAg status as soon as possible and, if mother is HBsAg-positive, also administer HBIG to infants weighing 2,000 grams or more as soon as possible, but no later than age 7 days.

   Doses following the birth dose:
   - The second dose should be administered at age 1 or 2 months. Monovalent HepB vaccine should be used for doses administered before age 6 weeks.
   - Infants who did not receive a birth dose should receive 3 doses of a HepB-containing vaccine on a schedule of 0, 1 to 2 months, and 6 months, starting as soon as feasible (see figure 2).
   - Administer the second dose 1 to 2 months after the first dose (minimum interval of 4 weeks); administer the third dose at least 8 weeks after the second dose AND at least 16 weeks after the **first** dose. The final (third or fourth) dose in the HepB vaccine series should be administered **no earlier than age 24 weeks**.
   - Administration of a total of 4 doses of HepB vaccine is permitted when a combination vaccine containing HepB is administered after the birth dose.

   Catch-up vaccination:
   - Unvaccinated persons should complete a 3-dose series.
   - A 2-dose series (doses separated by at least 4 months) of adult formulation Recombivax HB is licensed for use in children aged 11 through 15 years.
   - For other catch-up guidance, see Figure 2.

2. **Rotavirus (RV) vaccines. (Minimum age: 6 weeks for both RV1 [Rotarix] and RV5 [RotaTeq])**
Routine vaccination:
Administer a series of RV vaccine to all infants as follows:
   1. If Rotarix is used, administer a 2-dose series at ages 2 and 4 months.
   2. If RotaTeq is used, administer a 3-dose series at ages 2, 4, and 6 months.
   3. If any dose in the series was RotaTeq or vaccine product is unknown for any dose in the series, a total of 3 doses of RV vaccine should be administered.

   Catch-up vaccination:
   - The maximum age for the first dose in the series is 14 weeks, 6 days; vaccination should not be initiated for infants aged 15 weeks, 0 days, or older.
   - The maximum age for the final dose in the series is 8 months, 0 days.
   - For other catch-up guidance, see Figure 2.

3. **Diphtheria and tetanus toxoids and acellular pertussis (DTaP) vaccine. (Minimum age: 6 weeks. Exception: DTaP-IPV [Kinrix, Quadracel]: 4 years)**
Routine vaccination:
   - Administer a 5-dose series of DTaP vaccine at ages 2, 4, 6, 15 through 18 months, and 4 through 6 years. The fourth dose may be administered as early as age 12 months, provided at least 6 months have elapsed since the third dose.
   - Inadvertent administration of fourth DTaP dose early: If the fourth dose of DTaP was administered at least 4 months after the third dose of DTaP and the child was 12 months of age or older, it does not need to be repeated.

   Catch-up vaccination:
   - The fifth dose of DTaP vaccine is not necessary if the fourth dose was administered at age 4 years or older.
   - For other catch-up guidance, see Figure 2.

4. ***Haemophilus influenzae* type b (Hib) conjugate vaccine. (Minimum age: 6 weeks for PRP-T [ActHIB, DTaP-IPV/Hib (Pentacel), Hiberix, and Hib-MenCY (MenHibrix)], PRP-OMP [PedvaxHIB])**
Routine vaccination:
   - Administer a 2- or 3-dose Hib vaccine primary series and a booster dose (dose 3 or 4, depending on vaccine used in primary series) at age 12 through 15 months to complete a full Hib vaccine series.
   - The primary series with ActHIB, MenHibrix, Hiberix, or Pentacel consists of 3 doses and should be administered at ages 2, 4, and 6 months. The primary series with PedvaxHIB consists of 2 doses and should be administered at ages 2 and 4 months; a dose at age 6 months is not indicated.
   - One booster dose (dose 3 or 4, depending on vaccine used in primary series) of any Hib vaccine should be administered at age 12 through 15 months.
   - For recommendations on the use of MenHibrix in patients at increased risk for meningococcal disease, refer to the meningococcal vaccine footnotes and also to *MMWR* February 28, 2014 / 63(RR01):1-13, available at www.cdc.gov/mmwr/PDF/rr/rr6301.pdf.

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

Catch-up vaccination:

- If dose 1 was administered at ages 12 through 14 months, administer a second (final) dose at least 8 weeks after dose 1, regardless of Hib vaccine used in the primary series.
- If both doses were PRP-OMP (PedvaxHIB or COMVAX) and were administered before the first birthday, the third (and final) dose should be administered at age 12 through 59 months and at least 8 weeks after the second dose.
- If the first dose was administered at age 7 through 11 months, administer the second dose at least 4 weeks later and a third (and final) dose at age 12 through 15 months or 8 weeks after second dose, whichever is later.
- If first dose is administered before the first birthday and second dose administered at younger than 15 months, a third (and final) dose should be administered 8 weeks later.
- For unvaccinated children aged 15–59 months, administer only 1 dose.
- For other catch-up guidance, see Figure 2. For catch-up guidance related to MenHibrix, see the meningococcal vaccine footnotes and also *MMWR* February 28, 2014 / 63(RR01):1-13, available at www.cdc.gov/mmwr/PDF/rr/rr6301.pdf.

Vaccination of persons with high-risk conditions:

Children aged 12 through 59 months who are at increased risk for Hib disease, including chemotherapy recipients and those with anatomic or functional asplenia (including sickle cell disease), human immunodeficiency virus (HIV) infection, immunoglobulin deficiency, or early component complement deficiency, who have received either no doses or only 1 dose of Hib vaccine before age 12 months, should receive 2 additional doses of Hib vaccine, 8 weeks apart; children who received 2 or more doses of Hib vaccine before age 12 months should receive 1 additional dose.

- For patients younger than age 5 years undergoing chemotherapy or radiation treatment who received a Hib vaccine dose(s) within 14 days of starting therapy or during therapy, repeat the dose(s) at least 3 months following therapy completion.
- Recipients of hematopoietic stem cell transplant (HSCT) should be revaccinated with a 3-dose regimen of Hib vaccine starting 6 to 12 months after successful transplant, regardless of vaccination history; doses should be administered at least 4 weeks apart.
- A single dose of any Hib-containing vaccine should be administered to unimmunized* children and adolescents 15 months of age and older undergoing an elective splenectomy; if possible, vaccine should be administered at least 14 days before procedure.
- Hib vaccine is not routinely recommended for patients 5 years or older. However, 1 dose of Hib vaccine should be administered to unimmunized* persons aged 5 years or older who have anatomic or functional asplenia (including sickle cell disease) and unimmunized* persons 5 through 18 years of age with HIV infection.

** Patients who have not received a primary series and booster dose or at least 1 dose of Hib vaccine after 14 months of age are considered unimmunized.*

5. Pneumococcal vaccines. (Minimum age: 6 weeks for PCV13, 2 years for PPSV23)

Routine vaccination with PCV13:

- Administer a 4-dose series of PCV13 at ages 2, 4, and 6 months and at age 12 through 15 months.

Catch-up vaccination with PCV13:

- Administer 1 dose of PCV13 to all healthy children aged 24 through 59 months who are not completely vaccinated for their age.
- For other catch-up guidance, see Figure 2.

Vaccination of persons with high-risk conditions with PCV13 and PPSV23:

- All recommended PCV13 doses should be administered prior to PPSV23 vaccination if possible.
- For children aged 2 through 5 years with any of the following conditions: chronic heart disease (particularly cyanotic congenital heart disease and cardiac failure); chronic lung disease (including asthma if treated with high-dose oral corticosteroid therapy); diabetes mellitus; cerebrospinal fluid leak; cochlear implant; sickle cell disease and other hemoglobinopathies; anatomic or functional asplenia; HIV infection; chronic renal failure; nephrotic syndrome; diseases associated with treatment with immunosuppressive drugs or radiation therapy, including malignant neoplasms, leukemias, lymphomas, and Hodgkin disease; solid organ transplantation; or congenital immunodeficiency:
  1. Administer 1 dose of PCV13 if any incomplete schedule of 3 doses of PCV13 was received previously.
  2. Administer 2 doses of PCV13 at least 8 weeks apart if unvaccinated or any incomplete schedule of fewer than 3 doses of PCV13 was received previously.
  3. The minimum interval between doses of PCV13 is 8 weeks.
  4. For children with no history of PPSV23 vaccination, administer PPSV23 at least 8 weeks after the most recent dose of PCV13.
- For children aged 6 through 18 years who have cerebrospinal fluid leak; cochlear implant; sickle cell disease and other hemoglobinopathies; anatomic or functional asplenia; congenital or acquired immunodeficiencies; HIV infection; chronic renal failure; nephrotic syndrome; diseases associated with treatment with immunosuppressive drugs or radiation therapy, including malignant neoplasms, leukemias, lymphomas, and Hodgkin disease; generalized malignancy; solid organ transplantation; or multiple myeloma:
  1. If neither PCV13 nor PPSV23 has been received previously, administer 1 dose of PCV13 now and 1 dose of PPSV23 at least 8 weeks later.
  2. If PCV13 has been received previously but PPSV23 has not, administer 1 dose of PPSV23 at least 8 weeks after the most recent dose of PCV13.
  3. If PPSV23 has been received but PCV13 has not, administer 1 dose of PCV13 at least 8 weeks after the most recent dose of PPSV23.
- For children aged 6 through 18 years with chronic heart disease (particularly cyanotic congenital heart disease and cardiac failure), chronic lung disease (including asthma if treated with high-dose oral corticosteroid therapy), diabetes mellitus, alcoholism, or chronic liver disease, who have not received PPSV23, administer 1 dose of PPSV23. If PCV13 has been received previously, then PPSV23 should be administered at least 8 weeks after any prior PCV13 dose.
- A single revaccination with PPSV23 should be administered 5 years after the first dose to children with sickle cell disease or other hemoglobinopathies; anatomic or functional asplenia; congenital or acquired immunodeficiencies; HIV infection; chronic renal failure; nephrotic syndrome; diseases associated with treatment with immunosuppressive drugs or radiation therapy, including malignant neoplasms, leukemias, lymphomas, and Hodgkin disease; generalized malignancy; solid organ transplantation; or multiple myeloma.

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

Routine vaccination:

- Administer a 4-dose series of IPV at ages 2, 4, 6 through 18 months, and 4 through 6 years. The final dose in the series should be administered on or after the fourth birthday and at least 6 months after the previous dose.

Catch-up vaccination:

- In the first 6 months of life, minimum age and minimum intervals are only recommended if the person is at risk of imminent exposure to circulating poliovirus (i.e., travel to a polio-endemic region or during an outbreak).
- If 4 or more doses are administered before age 4 years, an additional dose should be administered at age 4 through 6 years and at least 6 months after the previous dose.
- 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.
- If both oral polio vaccine (OPV) and IPV were administered as part of a series, a total of 4 doses should be administered, regardless of the child's current age. If only OPV was administered, and all doses were given prior to age 4 years, 1 dose of IPV should be given at 4 years or older, at least 4 weeks after the last OPV dose.
- IPV is not routinely recommended for U.S. residents aged 18 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.

7. **Influenza vaccines. (Minimum age: 6 months for inactivated influenza vaccine [IIV], 18 years for recombinant influenza vaccine [RIV])**

Routine vaccination:

- Administer influenza vaccine annually to all children beginning at age 6 months. For the 2016–17 season, use of live attenuated influenza vaccine (LAIV) is not recommended.

For children aged 6 months through 8 years:

- For the 2016–17 season, administer 2 doses (separated by at least 4 weeks) to children who are receiving influenza vaccine for the first time or who have not previously received ≥2 doses of trivalent or quadrivalent influenza vaccine before July 1, 2016. For additional guidance, follow dosing guidelines in the 2016–17 ACIP influenza vaccine recommendations (see *MMWR* August 26, 2016;65(5):1-54, available at www.cdc.gov/mmwr/volumes/65/rr/pdfs/rr6505.pdf).
- For the 2017–18 season, follow dosing guidelines in the 2017–18 ACIP influenza vaccine recommendations.

For persons aged 9 years and older:

- Administer 1 dose.

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

Routine vaccination:

- Administer a 2-dose series of MMR vaccine at ages 12 through 15 months and 4 through 6 years. The second dose may be administered before age 4 years, provided at least 4 weeks have elapsed since the first dose.
- Administer 1 dose of MMR vaccine to infants aged 6 through 11 months before departure from the United States for international travel. These children should be revaccinated with 2 doses of MMR vaccine, the first at age 12 through 15 months (12 months if the child remains in an area where disease risk is high), and the second dose at least 4 weeks later.
- Administer 2 doses of MMR vaccine to children aged 12 months and older before departure from the United States for international travel. The first dose should be administered on or after age 12 months and the second dose at least 4 weeks later.

Catch-up vaccination:

- Ensure that all school-aged children and adolescents have had 2 doses of MMR vaccine; the minimum interval between the 2 doses is 4 weeks.

9. **Varicella (VAR) vaccine. (Minimum age: 12 months)**

Routine vaccination:

- Administer a 2-dose series of VAR vaccine at ages 12 through 15 months and 4 through 6 years. The second dose may be administered before age 4 years, provided at least 3 months have elapsed since the first dose. If the second dose was administered at least 4 weeks after the first dose, it can be accepted as valid.

Catch-up vaccination:

- Ensure that all persons aged 7 through 18 years without evidence of immunity (see *MMWR* 2007;56[No. RR-4], available at www.cdc.gov/mmwr/pdf/rr/rr5604.pdf) have 2 doses of varicella vaccine. For children aged 7 through 12 years, the recommended minimum interval between doses is 3 months (if the second dose was administered at least 4 weeks after the first dose, it can be accepted as valid); for persons aged 13 years and older, the minimum interval between doses is 4 weeks.

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

Routine vaccination:

- Initiate the 2-dose HepA vaccine series at ages 12 through 23 months; separate the 2 doses by 6 to 18 months.
- Children who have received 1 dose of HepA vaccine before age 24 months should receive a second dose 6 to 18 months after the first dose.
- For any person aged 2 years and older who has not already received the HepA vaccine series, 2 doses of HepA vaccine separated by 6 to 18 months may be administered if immunity against hepatitis A virus infection is desired.

Catch-up vaccination:

- The minimum interval between the 2 doses is 6 months.

Special populations:

- Administer 2 doses of HepA vaccine at least 6 months apart to previously unvaccinated persons who live in areas where vaccination programs target older children, or who are at increased risk for infection. This includes persons traveling to or working in countries that have high or intermediate endemicity of infection; men having sex with men; users of injection and non-injection illicit drugs; persons who work with HAV-infected primates or with HAV in a research laboratory; persons with clotting-factor disorders; persons with chronic liver disease; and 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. The first dose should be administered as soon as the adoption is planned, ideally, 2 or more weeks before the arrival of the adoptee.

11. **Meningococcal vaccines. (Minimum age: 6 weeks for Hib-MenCY [MenHibrix], 2 months for MenACWY-CRM [Menveo], 9 months for MenACWY-D [Menactra], 10 years for serogroup B meningococcal [MenB] vaccines: MenB-4C [Bexsero] and MenB-FHbp [Trumenba])**

Routine vaccination:

- Administer a single dose of Menactra or Menveo vaccine at age 11 through 12 years, with a booster dose at age 16 years.
- For children aged 2 months through 18 years with high-risk conditions, see "Meningococcal conjugate ACWY vaccination of persons with high-risk conditions and other persons at increased risk" and "Meningococcal B vaccination of persons with high-risk conditions and other persons at increased risk of disease" below.

Catch-up vaccination:

- Administer Menactra or Menveo vaccine at age 13 through 18 years if not previously vaccinated.
- If the first dose is administered at age 13 through 15 years, a booster dose should be administered at age 16 through 18 years, with a minimum interval of at least 8 weeks between doses.
- If the first dose is administered at age 16 years or older, a booster dose is not needed.
- For other catch-up guidance, see Figure 2.

Clinical discretion:

- Young adults aged 16 through 23 years (preferred age range is 16 through 18 years) who are not at increased risk for meningococcal disease may be vaccinated with a 2-dose series of either Bexsero (0, ≥1 month) or Trumenba (0, 6 months) vaccine to provide short-term protection against most strains of serogroup B meningococcal disease. The two MenB vaccines are not interchangeable; the same vaccine product must be used for all doses.
- If the second dose of Trumenba is given at an interval of <6 months, a third dose should be given at least 6 months after the first dose; the minimum interval between the second and third doses is 4 weeks.

Meningococcal conjugate ACWY vaccination of persons with high-risk conditions and other persons at increased risk:

Children with anatomic or functional asplenia (including sickle cell disease), children with HIV infection, or children with persistent complement component deficiency (includes persons with inherited or chronic deficiencies in C3, C5-9, properdin, factor D, factor H, or taking eculizumab [Soliris]):

- **Menveo**
  - *Children who initiate vaccination at 8 weeks.* Administer doses at ages 2, 4, 6, and 12 months.
  - *Unvaccinated children who initiate vaccination at 7 through 23 months.* Administer 2 primary doses, with the second dose at least 12 weeks after the first dose AND after the first birthday.
  - *Children 24 months and older who have not received a complete series.* Administer 2 primary doses at least 8 weeks apart.
- **MenHibrix**
  - *Children who initiate vaccination at 6 weeks.* Administer doses at ages 2, 4, 6, and 12 through 15 months.
  - If the first dose of MenHibrix is given at or after age 12 months, a total of 2 doses should be given at least 8 weeks apart to ensure protection against serogroups C and Y meningococcal disease.

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

- **Menactra**
  - **Children with anatomic or functional asplenia or HIV infection**
    - *Children 24 months and older who have not received a complete series.* Administer 2 primary doses at least 8 weeks apart. If Menactra is administered to a child with asplenia (including sickle cell disease) or HIV infection, do not administer Menactra until age 2 years and at least 4 weeks after the completion of all PCV13 doses.
  - **Children with persistent complement component deficiency**
    - *Children 9 through 23 months.* Administer 2 primary doses at least 12 weeks apart.
    - *Children 24 months and older who have not received a complete series.* Administer 2 primary doses at least 8 weeks apart.
  - **All high-risk children**
    - If Menactra is to be administered to a child at high risk for meningococcal disease, it is recommended that Menactra be given either before or at the same time as DTaP.

Meningococcal B vaccination of persons with high-risk conditions and other persons at increased risk of disease:
Children with anatomic or functional asplenia (including sickle cell disease) or children with persistent complement component deficiency (includes persons with inherited or chronic deficiencies in C3, C5-9, properdin, factor D, factor H, or taking eculizumab [Soliris]):

- **Bexsero or Trumenba**
  - *Persons 10 years or older who have not received a complete series.* Administer a 2-dose series of Bexsero, with doses at least 1 month apart, or a 3-dose series of Trumenba, with the second dose at least 1–2 months after the first and the third dose at least 6 months after the first. The two MenB vaccines are not interchangeable; the same vaccine product must be used for all doses.

For children who travel to or reside in countries in which meningococcal disease is hyperendemic or epidemic, including countries in the African meningitis belt or the Hajj:

- Administer an age-appropriate formulation and series of Menactra or Menveo for protection against serogroups A and W meningococcal disease. Prior receipt of MenHibrix is not sufficient for children traveling to the meningitis belt or the Hajj because it does not contain serogroups A or W.

For children at risk during an outbreak attributable to a vaccine serogroup:

- For serogroup A, C, W, or Y: Administer or complete an age- and formulation-appropriate series of MenHibrix, Menactra, or Menveo.
- For serogroup B: Administer a 2-dose series of Bexsero, with doses at least 1 month apart, or a 3-dose series of Trumenba, with the second dose at least 1-2 months after the first and the third dose at least 6 months after the first. The two MenB vaccines are not interchangeable; the same vaccine product must be used for all doses.

For MenACWY booster doses among persons with high-risk conditions, refer to *MMWR* 2013;62(RR02):1-22, at www.cdc.gov/mmwr/preview/mmwrhtml/rr6202a1.htm, *MMWR* June 20, 2014 / 63(24):527-530, at www.cdc.gov/mmwr/pdf/wk/mm6324.pdf, and *MMWR* November 4, 2016 / 65(43):1189-1194, at www.cdc.gov/mmwr/volumes/65/wr/pdfs/mm6543a3.pdf.
For other catch-up recommendations for these persons and complete information on use of meningococcal vaccines, including guidance related to vaccination of persons at increased risk of infection, see meningococcal *MMWR* publications, available at: www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/mening.html.

12. **Tetanus and diphtheria toxoids and acellular pertussis (Tdap) vaccine. (Minimum age: 10 years for both Boostrix and Adacel)**
Routine vaccination:
- Administer 1 dose of Tdap vaccine to all adolescents aged 11 through 12 years.
- Tdap may be administered regardless of the interval since the last tetanus and diphtheria toxoid-containing vaccine.
- Administer 1 dose of Tdap vaccine to pregnant adolescents during each pregnancy (preferably during the early part of gestational weeks 27 through 36), regardless of time since prior Td or Tdap vaccination.

Catch-up vaccination:
- Persons aged 7 years and older who are not fully immunized with DTaP vaccine should receive Tdap vaccine as 1 dose (preferably the first) in the catch-up series; if additional doses are needed, use Td vaccine. For children 7 through 10 years who receive a dose of Tdap as part of the catch-up series, an adolescent Tdap vaccine dose at age 11 through 12 years may be administered.
- Persons aged 11 through 18 years who have not received Tdap vaccine should receive a dose, followed by tetanus and diphtheria toxoids (Td) booster doses every 10 years thereafter.
- Inadvertent doses of DTaP vaccine:
  - If administered inadvertently to a child aged 7 through 10 years, the dose may count as part of the catch-up series. This dose may count as the adolescent Tdap dose, or the child may receive a Tdap booster dose at age 11 through 12 years.
  - If administered inadvertently to an adolescent aged 11 through 18 years, the dose should be counted as the adolescent Tdap booster.
- For other catch-up guidance, see Figure 2.

13. **Human papillomavirus (HPV) vaccines. (Minimum age: 9 years for 4vHPV [Gardasil] and 9vHPV [Gardasil 9])**
Routine and catch-up vaccination:
- Administer a 2-dose series of HPV vaccine on a schedule of 0, 6-12 months to all adolescents aged 11 or 12 years. The vaccination series can start at age 9 years.
- Administer HPV vaccine to all adolescents through age 18 years who were not previously adequately vaccinated. The number of recommended doses is based on age at administration of the first dose.
- For persons initiating vaccination before age 15, the recommended immunization schedule is 2 doses of HPV vaccine at 0, 6-12 months.
- For persons initiating vaccination at age 15 years or older, the recommended immunization schedule is 3 doses of HPV vaccine at 0, 1–2, 6 months.
- A vaccine dose administered at a shorter interval should be readministered at the recommended interval.
  - In a 2-dose schedule of HPV vaccine, the minimum interval is 5 months between the first and second dose. If the second dose is administered at a shorter interval, a third dose should be administered a minimum of 12 weeks after the second dose and a minimum of 5 months after the first dose.
  - In a 3-dose schedule of HPV vaccine, the minimum intervals are 4 weeks between the first and second dose, 12 weeks between the second and third dose, and 5 months between the first and third dose. If a vaccine dose is administered at a shorter interval, it should be readministered after another minimum interval has been met since the most recent dose.

Special populations:
- For children with history of sexual abuse or assault, administer HPV vaccine beginning at age 9 years.
- Immunocompromised persons*, including those with human immunodeficiency virus (HIV) infection, should receive a 3-dose series at 0, 1–2, and 6 months, regardless of age at vaccine initiation.
- Note: HPV vaccination is not recommended during pregnancy, although there is no evidence that the vaccine poses harm. If a woman is found to be pregnant after initiating the vaccination series, no intervention is needed; the remaining vaccine doses should be delayed until after the pregnancy. Pregnancy testing is not needed before HPV vaccination.

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

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AAP News

Infectious Diseases, Vaccine/Immunization, AAP Policy, News Articles

New table among changes to 2017 immunization schedules

by H. Cody Meissner, M.D., FAAP

The 2017 recommended childhood and adolescent immunization schedules include revised footnotes for eight vaccines and a new table addressing which vaccines may be indicated for people ages 0 through 18 years who have a specific medical indication.

The schedules are revised and approved annually by the Academy, the Advisory Committee on Immunization Practices (ACIP) 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.

Changes to figures

The 2017 format of Figure 1 is similar to the 2016 schedule consisting of a single table for people from birth through 18 years of age.

- The yellow bars indicate the recommended age range for all children and contain a notation indicating the recommended number of doses by age.
- The green bars indicate the recommended catch-up age.
- The purple bars designate the range for immunization for certain groups at high risk.
- The blue bars indicate the range of recommended doses for people in non-high-risk groups who may receive a vaccine, subject to individual decision-making.
- The white boxes show the ages when a vaccine is not recommended routinely.
- The columns that begin with a gray-shaded box indicate vaccine recommendations for school entry and at adolescent visits.

The following changes have been made to Figure 1 in the 2017 schedule:

- A column has been added for adolescents at 16 years of age. This age group has been separated from 17- to 18-year-olds to emphasize the need for a meningococcal conjugate vaccine (MenACWY) booster dose at age 16.
- Reference to live attenuated influenza vaccine (LAIV) has been removed from the influenza vaccine row.
- A blue bar has been added to the HPV vaccine row at 9-10 years to indicate that even in the absence of a high-risk condition, children may receive the HPV vaccine series at this age.

Figure 2 is the catch-up immunization schedule offering recommendations for children and adolescents who start late or are more than one month behind. As in previous years, the catch-up schedule is divided into sections for children 4 months through 6 years and children and adolescents 7 through 18 years. No changes have been made to the 2017 catch-up immunization figure.

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

The new Figure 3 indicates vaccines that may be administered during pregnancy or to children and adolescents

with an immunocompromising condition; kidney, heart or liver disease; a cochlear implant; a cerebrospinal fluid leak; asplenia; a complement deficiency or diabetes. Figure 3 in the childhood/adolescent schedule is similar to Figure 2 in the adult immunization schedule.

Changes to footnotes

Footnotes contain recommendations for routine vaccination, for catch-up vaccination as well as for vaccination of children and adolescents with high-risk conditions or in special circumstances. Recommendations in the figures should be read with the corresponding footnotes.

Changes have been made to the following footnotes:

- **Hepatitis B.** Updated recommendations reflect that a monovalent birth dose should be administered to all newborns within 24 hours of birth. Revised wording indicates that infants born to hepatitis B surface antigen (HBsAg) positive mothers should be tested for HBsAg and antibody to HBsAg at 9 through 12 months (rather than 9 through 18 months).
- ***Haemophilus influenzae* type b.** Comvax vaccine has been removed because the vaccine is no longer available commercially and all available doses have expired. Hiberix has been added to the list of vaccines that may be used for a primary vaccination series.
- **Pneumococcal conjugate**. References to PCV7 vaccine have been removed because all children who may have received PCV7 as part of a primary series have now aged out of the recommendation for pneumococcal vaccine.
- **Influenza**. Wording has been added to indicate that LAIV is not recommended for the 2016-'17 influenza season.
- **Meningococcal ACWY.** Recommendations now include vaccination of children with HIV infection.
- **Meningococcal B.** Wording has been added to note that people 16 through 23 years may be vaccinated based on clinical discretion. Updated recommendations regarding a two-dose Trumenba schedule have been added.
- **Tdap.** Revised wording indicates a preference for administration of one dose to pregnant women as early as possible during the 27 to 36 week gestational-age period. Wording is changed to indicate that for children 7 through 10 years who receive Tdap as part of a catch-up series, either Tdap or Td may be administered for the adolescent dose at 11 through 12 years.
- **Human papillomavirus.** Wording reflects that the number of recommended doses is based on age at administration of the first dose. Two doses are recommended for people starting the series before their 15th birthday, while three doses are recommended for those who start the series on or after their 15th birthday and for people with certain immunocompromising conditions. 2vHPV (Cervarix) has been removed from the schedule because it is no longer available and all available doses expired on Jan. 1.

In addition to publication of the schedules in the March issue of *Pediatrics*, the 2017 version of Figures 1-3, catch-up schedule, footnotes and job-aids are available on the AAP website and the CDC website. The schedules also are available on HealthyChildren.org.

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

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www.vaers.hhs.gov or by calling 800-822-7967. Additional information can be found in the AAP *Red Book* and at Red Book Online.

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Resources

- Statements from ACIP that contain details of recommendations for individual vaccines, including recommendations for children with high-risk conditions
- Information on new vaccine releases, vaccine supplies and interim recommendations resulting from vaccine shortages and statements on specific vaccines
- A parent-friendly vaccine schedule for children and adolescents
- An adult immunization schedule is published in February of each year.

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AAP News

Core flu vaccination recommendations carry over for 2017-'18

by Alyson Sulaski Wyckoff, Associate Editor

Core requirements for influenza immunization would remain the same for the 2017-'18 flu season, under a recommendation approved by a Centers for Disease Control and Prevention (CDC) committee Wednesday.

The Advisory Committee on Immunization Practices (ACIP) also recommended allowing any licensed, recommended and age-appropriate trivalent or quadrivalent inactivated influenza vaccine (IIV) or recombinant influenza vaccine (RIV) for pregnant women. The previous recommendation specified use of IIV for pregnant women.

In addition, the committee reiterated that the quadrivalent live attenuated influenza vaccine (LAIV4), which is given by nasal spray, not be used in any setting during the upcoming flu season. Last year, it was reported that in all pediatric age groups, LAIV did not have any statistically significant benefit in preventing influenza during three flu seasons. Additional data on LAIV4 is expected in October.

Also, Afluria (IIV3) now is indicated for people 5 years and older (down from 9 years and older).

The CDC director will review ACIP's recommendations. Those that are approved will be published as official recommendations in the *Morbidity and Mortality Weekly Report*. The Academy will review the CDC's changes and make official policy recommendations of its own.

Current CDC-AAP recommendations call for annual influenza vaccination for everyone 6 months of age and older who don't have contraindications.

During the current influenza season, 99 children have died, according to reports to the CDC. Overall, flu activity has been moderate, with peak incidence in mid-February and regional variation. Influenza A (H3N2) viruses have predominated overall, but since late March, influenza B viruses have been reported more frequently than A viruses.

Vaccine effectiveness for the current season showed "significant protectiveness" in children.

The U.S. influenza vaccine composition for the 2017-'18 season is as follows:

Trivalent vaccines:

- A/Michigan/45/2015 (H1N1) pdm09-like virus (updated)
- A/Hong Kong/4801/2014 (H3N2)-like virus
- B/Brisbane/60/2008-like virus (Victoria lineage)

Quadrivalent vaccines:

- Above three, plus B/Phuket/3073/2013-like virus (Yamagata lineage)

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Resources

- Influenza chapter in Red Book Online
- "Prevention and Control of Seasonal Influenza with Vaccines: Recommendations of the Advisory Committee on Immunization Practices - United States, 2016-17 Influenza Season,"

Immunization Case Scenarios

Case I

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

Should Have Received	Can Receive Today
–3 HepB @ birth, 1-2 mo, & 6-18 mo	1 Hep B
–3 RotaTeq@ 2, 4, & 6mo	NONE (don't give >32 wks)
–4 DTaP@ 2, 4, 6mo & 15-18mo	1 DTaP (no 5th dose if 4th >4yr)
–3 Hib@ 2, 4, & 12-15 mo*	1 Hib (no 2nd dose if 1st >15mo)
–4 PCV-13 @ 2, 4, 6, & 12-15 mo	1 PCV (no 2nd dose if 1st>24mo)
–3 IPV @ 2, 4, & 6-18 mo	1 IPV (no 4th dose if 3rd >4yr)
–1 MMR @ 12mo	1 MMR
–1 Varicella@ 12mo	1 VZV
–2 HepA @ 12-23mo	1 Hep A

Discussion Points

* Remember that for Hib, the number of doses in the primary series depends on the type of Hib vaccine. At WR-B, we used to have the PRP-T series (ActHib or Pentacel) which requires 2, 4, 6 mo shots, plus a booster at 12-15 mo. Now, we have the **PRP-OMP series** (Pedvax or Comvax) only require 2, 4 mo shots, plus a booster.

* Residents can discuss which of the vaccines in the "can receive today" column would be "most important" to receive, since all 8 vaccines probably should not be received at once. This decision may be based on prevalence of disease in community, likely exposures, etc. Also discuss which vaccines are available in combination (Pediarix, MMRV)

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

4 weeks. HepB, DTaP, IPV. (MMR and VZV given per usual at 4-6yrs; HepA in 6mo).

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?

Should Have Received	Y/N	Can Receive Today
–3 HepB @ birth, 1-2 mo, & 6-18 mo	0	1 Hep B
–3 RotaTeq@ 2, 4, & 6mo	0	NONE (don't give >32 wks)
–4 DTaP@ 2, 4, 6mo & 15-18mo + *1DTaP (4-6 yr)*	4	1 DTaP
–3 Hib@ 2, 4, & 12-15 mo *if PRP-OMP series*	3	1 Hib? (4th dose only if #1-3 @<12mo)
–4 PCV-13 @2, 4, 6, & 12-18 mo ***+ 1 PPV23 (>2yr)***	0	**1 PCV-13**
–3 IPV @ 2, 4, & 6-18 mo + *1 IPV (4-6yrs)*	3	1 IPV
–1 MMR @ 12mo + *1 MMR (4-6yrs)*	1	1 MMR
–1 Varicella@ 12mo + *1 VZV (4-6yrs)*	1	1 VZV
- Yearly Influenza	0	1 Influenza
–2 HepA @ 12-23mo	0	1 Hep A
- 2 MCV4 @ ≥2yrs	0	**1 MCV4**

Key Points for Sickle Cell Patients:

- In patients 6mo or older, **influenza vaccine** should be given annually.
- **Prevnar** (PCV13) should be administered as for children without sickle cell disease.
    * For children 24-59 months, *not previously immunized* with PCV7, 13 or PPV23, give TWO doses of PCV13 2 months apart, followed by 1st dose of PPV23 2 months later, followed by 2nd dose of PPV23 3-5 years later.
    * For children 5+ yrs *not previously immunized* with PCV7, 13 or PPV23, give ONE dose of PCV13, followed by 1st dose of PPV23 2 months later, followed by 2nd dose of PPV23 3-5 years later (if <10yrs) or 5 years later (if ≥10 yrs)
- **Menveo** (MCV-4) was approved by the FDA in Aug 2013 for age 2-23mo (previously >2yrs), and is given to at-risk children at 2, 4, 6, and 12months of age.
    * For children >2yrs (this patient!) who have not received a complete meningococcal series, administer 2 primary doses of MCV-4 at least 8 weeks apart.
    * In April 2015, WR-B began to carry Trumenba (Serotype B meningococcal vaccine) intended for pts ≥10yrs with complement def'y, aspenia, or amidst an outbreak.

Case III

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

Should Have Received	Y/N	Can Receive Today
–3 HepB @ birth, 1-2 mo, & 6-18 mo	0	1 Hep B
–3 RotaTeq@ 2, 4, & 6mo	0	NONE (don't give >32 wks)
–5 DTaP@ 2, 4, 6, 15-18mo & 4-6yr + **1Tdap (11-12yr)**	5	**1 Tdap**
–4 Hib@ 2, 4, 6, & 12-15 mo	4	COMPLETE
–4 PCV-13 @ 2, 4, 6, & 12-15 mo	0	1 PCV-13
–4 IPV @ 2, 4, 6-18 mo & 4-6yrs	4	COMPLETE
–2 MMR @ 12mo & 4-6yrs	2	COMPLETE
–2 Varicella@ 12mo & 4-6yrs	0	1 VZV
- Yearly Influenza	0	1 Influenza
–2 HepA @ 12-23mo	0	1 Hep A
- 3 HPV @ 11-12yrs	0	**1 HPV**
-1 MCV4 @11-12yrs	0	**1 MCV4**

Tdap, HPV, and MCV4 are key immunizations for adolescents. Below are other notes to consider when developing "catch-up schedule" for this patient:

* HepB: Complete 3-shot series (4 weeks, 8 weeks btwn doses)
* Tdap: Can give booster 5 years after last DTaP
* PCV-13: No further doses needed since 1st dose administered at >2yrs
* Varicella: Complete 2-shot series (4 weeks btwn doses), *if no evidence of immunity*
* Hep A: Complete 2-shot series (6mo btwn doses)
* HPV: Complete 3-shot series (2mo, 6mo btwn doses)

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?

Should Have Received	**Y/N**	**Can Receive Today**
–3 HepB @ birth, 1-2 mo, & 6-18 mo	3	"COMPLETED"
–3 RotaTeq@ 2, 4, & 6mo	0	NONE (don't give >32 wks)
–4 DTaP@ 2, 4, 6mo & 15-18mo	3	1 DTaP
–3 Hib@ 2, 4, & 12-15 mo	3	1 Hib? (4th dose only if #1-3 @<12mo)
–4 PCV-13 @ 2, 4, 6, & 12-15 mo	0	1 PCV-13
–3 IPV @ 2, 4, & 6-18 mo	3	"COMPLETED"
–1 MMR @ 12mo	0	"COMPLETED"
–1 Varicella@ 12mo	0	"COMPLETED"
–2 HepA @ 12-23mo	0	1 Hep A

From Red Book: Medical Evaluation of Internationally Adopted Children for Infectious Diseases.

- **PPD** or currently recommended testing for tuberculosis exposure (this should be done even if the child was immunized with the **BCG vaccine**).
- Evaluate immunization status by **checking antibody titers** for vaccines previously given (eg, diphtheria, tetanus, polio neutralizing titers) **OR repeat immunizations.** *(Exceptions may include children from foster homes in Korea and Guatemala.)*
- Testing for **tuberculosis, Hepatitis B, Hepatitis C, and HIV** should be repeated after the child has been home 6 months. (Some children may not respond initially if the incubation period is inadequate or if they are malnourished.)

See CDC website for other options: http://www.cdc.gov/vaccines/parents/adoptions.html

"**Written records are more likely to predict protection if the vaccines, dates of administration, intervals between doses, and age at the time of vaccination are comparable to U.S. recommendations.** Although vaccines with inadequate potency have been produced in other countries, the majority of vaccines used worldwide are produced with adequate quality control standards and are potent. . . Health-care providers may use one of multiple approaches if the immunogenicity of vaccines administered to persons outside the United States is in question. Repeating the vaccinations is an acceptable option that usually is safe and prevents the need to obtain and interpret serologic tests. If avoiding unnecessary injections is desired, judicious use of serologic testing might help determine which vaccinations are needed. For some vaccines, the most readily available serologic tests cannot document protection against infection."

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

Protection against infectious diseases is an important issue in preparing children and adults for international travel. Clinicians can obtain specific knowledge of available vaccines and prophylaxis for certain conditions from the American Academy of Pediatrics *2009 Report of the Committee on Infectious Diseases (Red Book®)* and the travelers' health site of the Centers for Disease Control and Prevention. Travel to India involves a potentially increased exposure to malaria, hepatitis A, measles, polio, and *Salmonella typhi*. However, there are other considerations in recommending various preventive measures for travelers.

Measles may be encountered more commonly in many parts of the world, including India. Accordingly, measles vaccine is recommended for 6- to 11-month-old children, and the 7-month-old girl in the vignette should be given a dose of measles vaccine. She still will require two doses of measles-containing vaccine after 1 year of age because the immune response may be suboptimal at her young age. If the 9-year-old boy is up to date on immunizations, he requires no additional measles vaccination.

Although exposure to malaria is a concern on a prolonged trip to India, resistance to chloroquine is a major concern in this region, as it is in all of South and Southeast Asia, sub-Saharan Africa, and tropical areas of South America. Available agents for resistant malaria prophylaxis in infants and children include atovaquone/proguanil and mefloquine. Doxycycline can be used in children older than 8 years of age.

Hepatitis A is a concern, but hepatitis A vaccine is not approved in children younger than 1 year of age. Intramuscular immunoglobulin is recommended for children younger than 1 year of age, as the baby in the vignette, traveling to an endemic area. The boy should receive his first dose of hepatitis A vaccine at least 2 to 4 weeks before departure if he has not been immunized previously, with completion of the two-dose series 6 to 12 months later.

Although polio exposure may be a concern, if both children are up to date in their vaccination series, no additional polio vaccine is indicated. Finally, typhoid vaccine might be indicated for a trip to India that lasts longer than 2 weeks, but neither of the two licensed vaccines is indicated in children younger than 2 years of age.

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**

The progressive paroxysmal cough progressing over 3 weeks accompanied by posttussive vomiting reported by the girl in the vignette is typical for adolescent pertussis. The duration of disease is 6 to 10 weeks, and complications in adolescents and adults may include sleep disturbances, secondary pneumonia, and vomiting. Immunity to pertussis wanes 6 or more years after vaccination, which makes adolescents and adults susceptible after completing the recommended childhood pertussis vaccine series at 4 to 6 years of age.

In recognition of the increased occurrence of pertussis in this age range and with the demonstrated safety and efficacy of attenuated acellular pertussis booster vaccines (ie, tetanus toxoid, reduced diphtheria toxoid, acellular pertussis [Tdap]), the Advisory Committee on Immunization Practices of the Centers for Disease Control and Prevention recommended in 2005 that a single dose of Tdap be administered at the routine 11- to 12-year-old health supervision visit. A single dose of Tdap also should be administered more than 5 years after the last tetanus toxoid, reduced diphtheria toxoid (Td) dose for individuals up to 64 years of age. In high-risk situations, the dose can be administered as soon as 2 years after the last Td vaccination. Accordingly, determining whether the girl in the vignette has received a dose of Tdap since 11 years of age would help confirm the suspicion of pertussis.

The most common signs and symptoms of gastroesophageal reflux are heartburn, regurgitation, and dysphagia, not primarily coughing spasms. A history of international travel might help support concerns of exposure to tuberculosis. In addition, such travel might increase the individual's exposure to other respiratory agents such as influenza (based on seasonality and hemisphere) and other vaccine-preventable diseases such as pertussis, but supporting the diagnosis of pertussis would be better aided by knowing the history of Tdap immunization. A number of respiratory infections can be transmitted to people from pets or animals (eg, Q fever, Bordetella bronchiseptica), but these infections are much less common than pertussis and are not as consistent with the clinical illness described. Spelunking (or caving) in areas of the eastern and central United States may increase the risk for exposure to histoplasmosis from bird or bat droppings in the caves. Clinically, histoplasmosis in the healthy host usually is asymptomatic. Acute pulmonary histoplasmosis presents with more of an influenza-like illness that resolves over 2 days to 2 weeks.

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*

Children who have not received the *Haemophilus influenzae* type b (Hib) vaccine are at risk for illnesses commonly caused by this organism, including buccal and periorbital cellulitis (as described for the boy in the vignette), pyogenic arthritis, epiglottitis, and bacterial meningitis. *Neisseria meningitidis* usually does not cause a facial cellulitis, and *Staphylococcus aureus* and *Streptococcus pyogenes* are less likely pathogens in the absence of a history of a break in the skin. *S pneumoniae* can be the cause of a nontraumatic facial cellulitis in Hib-vaccinated children, but in an unvaccinated child, Hib would be the most likely pathogen.

Hib disease can be verified by recovery of the organism from a sterile site (eg, blood, cerebrospinal fluid, joint fluid) or by urine antigen testing. Once the organism is isolated, antimicrobial susceptibility testing is important because approximately 30% to 40% of Hib isolates produce beta-lactamase, making these organisms resistant to ampicillin.

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

In the United States, mumps vaccine is administered as part of the measles-mumps-rubella (MMR) vaccine routinely to children at 12 to 15 months of age, with a second dose of MMR typically administered at 4 to 6 years of age. Protective efficacy of the vaccine is estimated to be more than 95%. In cases of exposure, such as described in the vignette, it is important to ensure that the exposed person has received the recommended number of doses of MMR vaccine because mumps outbreaks have occurred in people in highly immunized populations who previously have received only a single dose of mumps-containing vaccine. Therefore, the most appropriate action is to confirm with the mother that her son has received two doses of MMR vaccine.

Mumps vaccine has not been demonstrated to be effective in preventing infection after exposure. However, the vaccine can be administered after exposure to provide protection against subsequent exposures in persons who are not fully vaccinated. Fully immunized persons do not need to be excluded from school after exposure. Students who are not fully immunized are excluded from school until they are immunized, after which they can be readmitted immediately to school. Students who refuse mumps vaccination because of medical, religious, or other reasons should be excluded from school for at least 26 days after the onset of parotitis in the last person who has mumps in the affected school. Persons who have mumps are excluded from school for 9 days from the onset of their parotid swelling.

Immune globulin (IG) and mumps IG are not effective as postexposure prophylaxis measures. In fact, mumps IG no longer is available in the United States. Treatment of the disease is supportive; no effective antiviral agents are available.

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

Health-care personnel are in contact with patients who may have contagious, vaccine-preventable diseases and are at increased risk for contracting such diseases. Further, the employee who becomes infected is at risk for transmitting the disease to other patients who are susceptible to the disease. Therefore, all health-care personnel should protect themselves and susceptible patients by receiving appropriate immunizations. The vaccine-preventable infections that are of special concern to people involved in the health care of children include rubella, measles, mumps, hepatitis B, influenza, varicella, and tuberculosis. The immune status of the health-care worker against these diseases should be documented at the time of employment.

Persons found to be susceptible should receive the appropriate vaccine or vaccine series for the disease to which they are susceptible. Diphtheria, hepatitis A, meningococcal disease, and tetanus are not commonly transmitted by patients in a health-care setting and do not require documentation of immune status.