Immunization and Prophylaxis

Karen J. Marcdante MD, , Robert M. Kliegman MD, and Abigail M. Schuh MD, MMHPE

Nelson Essentials of Pediatrics, Chapter 94, 381-385

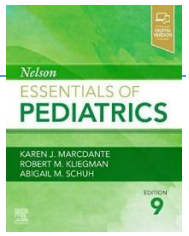
با توجه به برنامه واکسیناسیون کشوری شکل های 94.1 و 94.2 از مباحث سوال دانشجویی حذف هستند.

Immunization

Childhood immunization has markedly reduced the impact of major infectious diseases. **Active immunization** induces immunity through the administration of all or part of a microorganism or a modified product of a microorganism (e.g., toxoid). **Passive immunization** involves administration of protective antibodies and includes transplacental transfer of maternal antibodies and the administration of preformed antibody, either as immunoglobulin or as monoclonal antibody.

Vaccinations may be with live-attenuated viruses (measles, mumps, rubella [MMR], varicella, nasal influenza, oral polio, rotavirus), inactivated or killed viruses (intramuscular polio, hepatitis A, intramuscular influenza), recombinant products (hepatitis B, human papillomavirus), or immunogenic components of bacteria (pertussis, *Haemophilus influenzae* type b, *Neisseria meningitidis* , and *Streptococcus pneumoniae*), including toxoids (diphtheria, tetanus). Many purified polysaccharides are T-cell independent antigens that initiate B-cell proliferation without involvement of CD4 T lymphocytes and are poor immunogens in children younger than 2 years of age. Conjugation of a polysaccharide to a **protein carrier** induces a T-cell dependent response in infants and creates immunogenic vaccines for *H. influenzae* type b, *S. pneumoniae* , and *N. meningitidis* .

Childhood immunization standards and recommendations in the United States (Figs. 94.1 and 94.2) are formulated by the Advisory Committee on Immunization Practices of the Centers for Disease Control and Prevention (ACIP), the American Academy of Pediatrics, and the American Academy of Family Physicians. In the United States, due to state laws requiring immunization for school entry, approximately 95% of children entering kindergarten are vaccinated for the common infectious diseases. The ACIP recommends that children in the United States routinely receive vaccines against 16 diseases (see Fig. 94.1). This schedule includes up to 23 injections in four to five visits by 18 months of age. Children who are at increased risk for pneumococcal infections should receive the pneumococcal polysaccharide vaccine as well. Infants and children who are at increased risk for meningococcal infections should receive the two- or four-dose meningococcal series depending on age. Children who are behind in immunization should receive catch-up immunizations as rapidly as feasible. Infants born prematurely, regardless of birthweight, should be vaccinated at the same chronological age and according to the same schedule as full-term infants and children (see Fig. 94.2). The single exception to this practice is providing hepatitis B vaccine at 1 month of age instead of at birth for infants weighing less than 2,000 g if the mother is hepatitis B virus surface antigen (HB_sAg) negative. Vaccines for adolescents should be given at 11–12 years of age (see Fig. 94.1), with completion of any vaccine series at 13–18 years of age and a booster for *N. meningitidis* at 16 years of age.



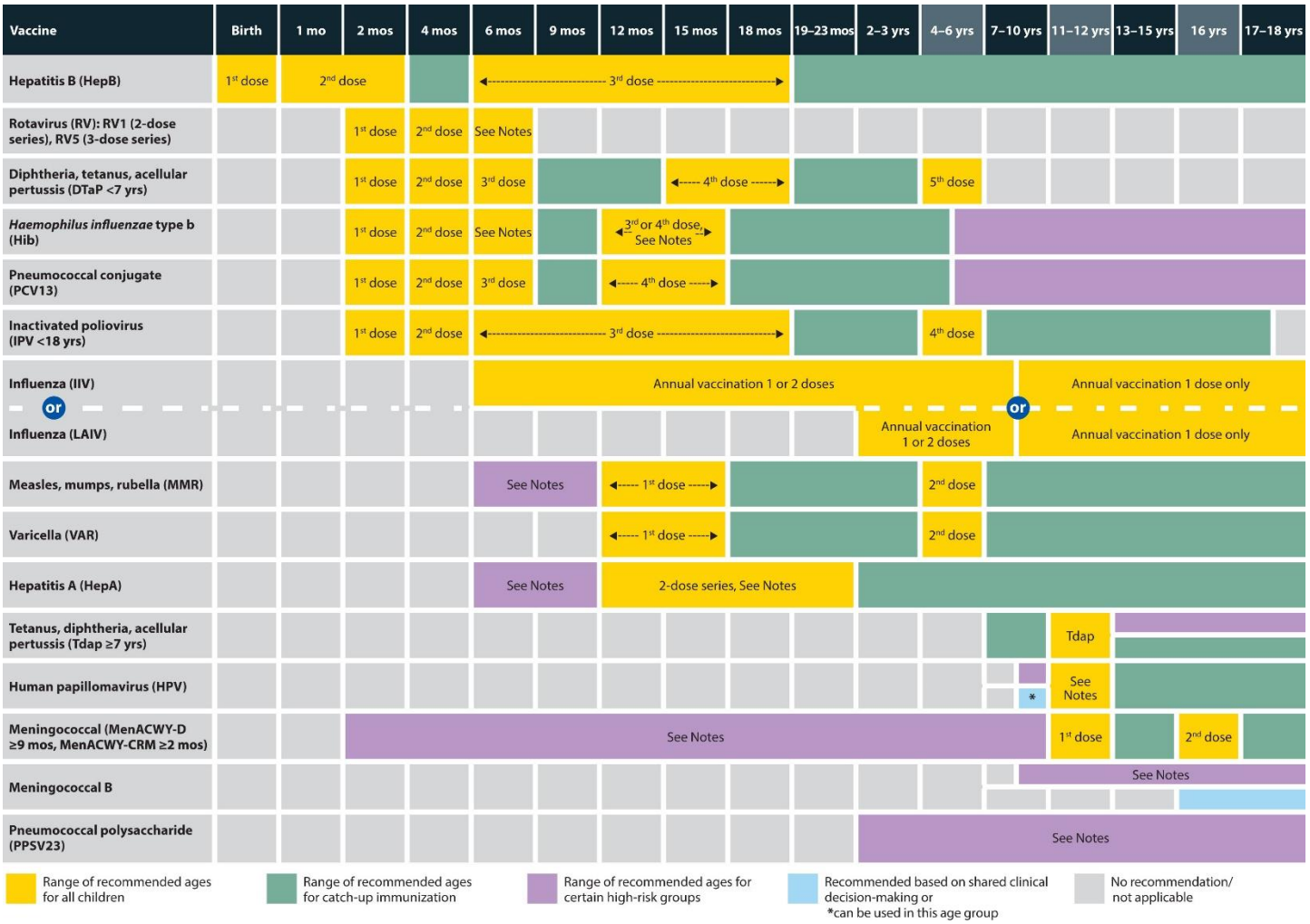
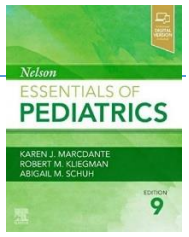


Figure 94.1

Recommended immunization schedules for persons aged 0 through 18 years—United States, 2020. These recommendations should be read with the notes provided in the original schedule (see link in credit). For those who fall behind or start late, provide catch-up vaccination at the earliest opportunity as indicated by the green bars. To determine minimum intervals between doses, see the catch-up schedule (Fig. 94.2). School entry and adolescent vaccine age groups are shaded in dark gray along the top row.

(Approved by the Advisory Committee on Immunization Practices; American Academy of Pediatrics; American Academy of Family Physicians; and American College of Obstetricians and Gynecologists; Courtesy of the U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. https://www.cdc.gov/vaccines/schedules/hcp/imz/child-adolescent.html .)



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	Birth	**4 weeks**	**8 weeks *and* at least 16 weeks after first dose.** Minimum age for the final dose is 24 weeks.		
Rotavirus	6 weeks Maximum age for first dose is 14 weeks, 6 days	**4 weeks**	**4 weeks** Maximum age for final dose is 8 months, 0 days.		
Diphtheria, tetanus, and acellular pertussis	6 weeks	**4 weeks**	**4 weeks**	**6 months**	**6 months**
Haemophilus influenzae type b	6 weeks	**No further doses needed** if first dose was administered at age 15 months or older. **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 previous dose was administered at age 15 months or older. **4 weeks** 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)** 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.	**8 weeks (as final dose)** This dose only necessary for children age 12 through 59 months who received 3 doses before the 1st birthday.	
Pneumococcal conjugate	6 weeks	**No further doses needed** for healthy children if first dose was administered at age 24 months or older. **4 weeks** if first dose was 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 previous dose administered at age 24 months or older. **4 weeks** if current age is younger than 12 months and previous dose was administered at <7 months old. **8 weeks (as final dose for healthy children)** if previous dose was administered 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.	**8 weeks (as final dose)** This dose only necessary for children age 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 weeks	**4 weeks**	**4 weeks** if current age is < 4 years. **6 months (as final dose)** if current age is 4 years or older.	**6 months** (minimum age 4 years for final dose).	
Measles, mumps, rubella	12 months	**4 weeks**			
Varicella	12 months	**3 months**			
Hepatitis A	12 months	**6 months**			
Meningococcal ACWY	2 months MenACWY-CRM 9 months MenACWY-D	**8 weeks**	See Notes	See Notes	
Children and adolescents age 7 through 18 years					
Meningococcal ACWY	Not applicable (N/A)	**8 weeks**			
Tetanus, diphtheria; tetanus, diphtheria, and acellular pertussis	7 years	**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	9 years	**Routine dosing intervals are recommended.**			
Hepatitis A	N/A	**6 months**			
Hepatitis B	N/A	**4 weeks**	**8 weeks *and* at least 16 weeks after first dose.**		
Inactivated poliovirus	N/A	**4 weeks**	**6 months** A fourth dose is not necessary if the third dose was administered at age 4 years or older and at least 6 months after the previous dose.	A fourth dose of IPV is indicated if all previous doses were administered at <4 years or if the third dose was administered <6 months after the second dose.	
Measles, mumps, rubella	N/A	**4 weeks**			
Varicella	N/A	**3 months** if younger than age 13 years. **4 weeks** if age 13 years or older.			

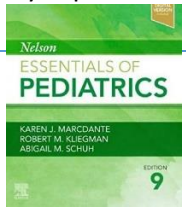
Figure 94.2

Catch-up immunization schedule for persons aged 4 months to 18 years who start late or who are more than 1 month behind—United States, 2020. These recommendations provide 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 schedule in conjunction with Fig. 94.1 and the notes included in the original recommendations (see link in credit).

(Approved by the Advisory Committee on Immunization Practices; American Academy of Pediatrics; American Academy of Family Physicians; and American College of Obstetricians and Gynecologists; Courtesy of the U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. https://www.cdc.gov/vaccines/schedules/hcp/imz/catchup.html .)

Vaccines should be administered after obtaining informed consent. The **National Childhood Vaccine Injury Act** requires that all health care providers provide parents or patients with copies of **Vaccine Information Statements** prepared by the Centers for Disease Control and Prevention (http://www.cdc.gov/vaccines/hcp/vis/index.html) before administering each vaccine dose.

Most vaccines are administered by intramuscular or subcutaneous injection. The preferred sites for administration are the anterolateral aspect of the thigh in infants and the deltoid region in children and adults. Multiple vaccines can be administered simultaneously at anatomically separate sites (different limbs or separated by >1 in) without diminishing the immune response. MMR and varicella vaccines should be administered simultaneously or more than 28 days apart. The



conjugate and polysaccharide pneumococcal vaccines should be spaced at least 8 weeks apart when both are indicated, and the conjugate vaccine should be administered first, if possible. Tuberculosis testing, either with a skin test or gamma interferon release blood test, can be performed at the time of vaccination. If tuberculosis testing is not performed at the same visit as MMR vaccination, then testing should be delayed for 6 weeks as MMR vaccination can temporarily suppress response to tuberculin antigens. Administration of blood products and immunoglobulin can diminish response to live-virus vaccines administered before the recommended interval.

General contraindications to vaccination include serious allergic reaction (anaphylaxis) after a previous vaccine dose or to a vaccine component, immunocompromised states, or pregnancy (live-virus vaccines), and moderate or severe acute illness with or without fever. History of *anaphylactic-like* reactions to eggs has historically been a contraindication to influenza and yellow fever vaccines, which are produced in embryonated chicken eggs; however, in 2016 the ACIP recommended that even persons with severe egg allergy could receive any licensed influenza vaccine. Current preparations of measles and mumps vaccines, which are produced in chick embryo fibroblast tissue culture, do not contain significant amounts of egg proteins and may be administered without testing children with history of egg allergy. Mild acute illness with or without fever, convalescent phase of illness, recent exposure to infectious diseases, current antimicrobial therapy, breast-feeding, mild to moderate local reaction or low-grade to moderate fever after previous vaccination, and a history of penicillin or other nonvaccine allergy or receiving allergen extract immunotherapy are **not contraindications** to immunization.

Severe immunosuppression resulting from congenital immunodeficiency, HIV infection, leukemia, lymphoma, cancer therapy, or a prolonged course of high-dose corticosteroids (≥2 mg/kg/day for >2 weeks) predisposes to complications and is a contraindication for live-virus vaccines. For HIV-infected children who do not have evidence of severe immunosuppression, MMR vaccination is recommended as per the regular schedule. Varicella vaccine is contraindicated for persons with cellular immunodeficiency but is recommended for persons with impaired humoral immunity (hypogammaglobulinemia or dysgammaglobulinemia) and at 12 months of age for HIV-infected children without evidence of severe immunosuppression, given as two doses 3 months apart. Rotavirus vaccine should not be given to children with a history of intussusception or severe combined immunodeficiency syndromes.

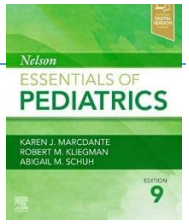
The National Childhood Vaccine Injury Act requires that clinically significant adverse events after vaccination be reported to the **Vaccine Adverse Event Reporting System (VAERS)** (http://www.vaers.hhs.gov or 800-822-7967). Suspected cases of vaccine-preventable diseases should be reported to state or local health department. The act also established the **National Vaccine Injury Compensation Program**, a no-fault system in which persons thought to have suffered an injury or death as a result of administration of a covered vaccine can seek compensation.

Prophylaxis

Prophylaxis may include antibiotics, immunoglobulin or monoclonal antibody, and vaccine, alone or in combination. They may be used preexposure, for perinatal exposure, and postexposure for persons at increased risk for infection. **Primary prophylaxis** is used to prevent infection before a first occurrence. **Secondary prophylaxis** is used to prevent recurrence after a first episode.

Meningococcus

Primary prophylaxis to all close contacts of index cases of *N. meningitidis* infection should be administered as soon as possible (see Chapter 100). Prophylaxis is recommended for all household contacts, especially young children; child care or preschool contacts in the 7 days before illness onset; contacts with direct exposure to the index patient's secretions through kissing, sharing of toothbrushes or eating utensils in the 7 days before illness onset; and for mouth-to-mouth resuscitation or unprotected contact during endotracheal intubation within 7 days before illness onset. Prophylaxis is also recommended for contacts who frequently sleep or eat in the same dwelling as the index patient or passengers seated directly next to the index case during airline flights lasting longer than 8 hours. Chemoprophylaxis is not recommended



for casual contacts with no history of direct exposure to the patient's oral secretions (school or work), indirect contact with the index patient, or medical personnel without direct exposure to the patient's oral secretions. Rifampin twice daily for 2 days and ceftriaxone once (all ages) and ciprofloxacin once for those 18 years of age and older (unless there is no acceptable alternative available) are the recommended regimens. Azithromycin may be used in the case of resistant organisms.

Tetanus

All postexposure wound treatment begins with immediate, thorough cleansing using soap and water, removal of foreign bodies, and debridement of devitalized tissue. Tetanus prophylaxis after wounds and injuries includes vaccination of persons with incomplete immunization and tetanus immunoglobulin for contaminated wounds (soil, feces, saliva), puncture wounds, avulsions, and wounds resulting from missiles, crushing, burns, and frostbite (Table 94.1).

Table 94.1 Guide to Tetanus Prophylaxis in Routine Wound Management

From *Kimberlin DW, Barnett ED, Lynfield R, et al., eds. Red Book: 2021–2024 Report of the Committee on Infectious Diseases. Itasca, IL: American Academy of Pediatrics; 2021.*

History of adsorbed tetanus toxoid (doses)	Clean, minor wounds		All other wounds *	
	DTaP, Tdap, OR Td †	TIG ‡	DTaP, Tdap, OR Td †	TIG ‡
Fewer than 3 or unknown	Yes	No	Yes	Yes
3 or more	No if <10 yr since last tetanus-containing vaccine dose	No	No if <5 yr since last tetanus-containing vaccine dose	No
	Yes if ≥10 yr since the last tetanus toxoid-containing vaccine dose	No	Yes if ≥5 yr since the last tetanus toxoid-containing vaccine dose	No

Tdap , Tetanus and diphtheria toxoids, acellular pertussis vaccine; *Td* , tetanus-diphtheria toxoid; *TIG* , tetanus immunoglobulin.

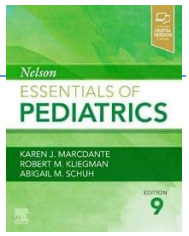
* Such as, but not limited to, wounds contaminated with dirt, feces, soil, or saliva; puncture wounds; avulsions; and wounds resulting from missiles, crushing, burns, and frostbite.

† Tdap is preferred for children ≥7 years of age who have never received Tdap.

‡ Immune globulin intravenous should be used if TIG is not available.

Rabies

Rabies immune globulin (RIG) and rabies vaccine are extremely effective for prophylaxis after exposure to rabies but are of no known benefit after symptoms appear. Because rabies is one of the deadliest infections, recognition of potential exposure and prophylaxis are crucial. Any healthy-appearing domestic animal (dog, cat) responsible for an apparently unprovoked bite should be observed for 10 days for signs of rabies without immediate treatment of the victim. Prophylaxis should be administered if the animal is rabid or suspected to be rabid, or if the animal develops signs of rabies while under observation. A captured wild animal should be euthanized (by animal control officials) without a period of observation and its brain examined for evidence of rabies. If the biting animal is not captured, particularly if it is a wild animal of a species known to harbor the virus in the region, rabies should be presumed, and prophylaxis administered to the victim. Bats, raccoons, skunks, foxes, coyotes, and bobcats are the most important wild animal potential sources of rabies infection. Prophylaxis also should be provided following exposure to a bat for persons who might be unaware or unable to relate that a bite or direct contact has occurred, such as a sleeping child, or an unattended infant. Local public health departments are important resources for determining rabies risk based on local epidemiology.



All rabies postexposure management begins with immediate thorough cleansing of the bite using soap and water. RIG at a dose of 20 IU/kg should be administered, with the full dose of RIG infiltrated subcutaneously into the area around the wound, if possible. Any remaining RIG that cannot be infiltrated into the wound should be administered as an intramuscular injection. Inactivated rabies vaccine should be administered simultaneously as soon as possible, at a site away from where RIG was administered, with additional vaccine doses at 3, 7, and 14 days.

Pearls for Practitioners

• Purified polysaccharide vaccines are poor immunogens for children younger than 2 years. Conjugation of a polysaccharide to a protein carrier creates immunogenic vaccines for Haemophilus influenzae type b, Streptococcus pneumoniae , and Neisseria meningitidis for this age group.

• Contraindications to vaccination include anaphylaxis to prior immunization and immunocompromised patients (live-virus vaccines).

• Administration of blood products and immunoglobulin can diminish response to live-virus vaccines if administered before the recommended interval.