Recommended Vaccines for Adolescent Patients

Gregory H. Bennett, DO Kelly Leite, DO

From the Department of Pediatrics at Penn State Hershey Children's Hospital.

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Address correspondence to Gregory H. Bennett, DO, Department of Pediatrics, Penn State Hershey Children's Hospital, PO Box 850, H085, Hershey, PA 17033-0850.

E-mail: gbennett@hmc.psu.edu



Vaccination is a safe and effective tool in the prevention of serious and deadly infectious diseases. The vaccinations delivered at routine adolescent visits are an integral part of preventing infection, as well as reducing school absenteeism as a result of illness. **Current recommendations by the Advisory Committee** on Immunization Practices include vaccinating during a single visit at age 11 or 12 years against pathogens including Neisseria meningitidis, which has been shown to cause invasive meningococcal infections; Bordetella pertussis, which has been shown to cause pertussis (whooping cough); and human papillomavirus, which has been shown to cause cervical cancer and genital warts. Additionally, annual influenza vaccination is recommended for adolescents without contraindications to the vaccine. In the present article, the authors summarize current recommendations for adolescent vaccines and their formulations, the infections that they prevent, contraindications to administration, vaccination rates, and the most commonly reported adverse events.

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accines continue to be a mainstay of public health in preventing infectious diseases. The vaccinations delivered at routine adolescent health maintenance visits are an integral part of this prevention,1,2 considering that adolescents (aged 10 to 19 years) and young adults (aged 20 to 24 years) make up approximately 21% of the US population.3 Adolescent vaccination also helps to fulfill 2 primary goals of the Healthy People 2020 initiative: to "decrease school absenteeism among adolescents due to illness or injury" and to "increase the proportion of adolescents who have had a wellness checkup in the past 12 months."4 According to 2008 data, 68.7% of adolescents aged 10 to 17 years had a wellness checkup in the past 12 months and 5% of adolescents aged 12 to 17 years missed 11 or more school days as a result of illness or injury in the previous 12 months.4 There is certainly room for improvement in these rates, and vaccines administered in adolescence directly influence both of these goals. Despite progress, it is estimated that approximately "300 children in the United States die each year from vaccine-preventable disease."5

Annual wellness visits are generally recommended for adolescents aged 11 to 17 years, with recommended adolescent vaccines administered at age 11 or 12 years (*Figure 1* and *Figure 2*). The number of recommended vaccines for pediatric patients has increased over the past decade. Current recommendations by the Advisory Committee on Immunization Practices (ACIP) include vaccinating

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during a single visit at age 11 or 12 years against pathogens including Neisseria meningitidis, which has been shown to cause invasive meningococcal infections; Bordetella pertussis, which has been shown to cause pertussis (whooping cough); and human papilloma virus (HPV), which has been shown to cause cervical cancer and genital warts.1 Additionally, current guidelines recommend vaccination against the diseases of measles, mumps, rubella, varicella, hepatitis B, and polio for those who have not previously received these vaccines. Annual influenza vaccination is recommended for individuals older than 6 months who do not have contraindications.2

It is estimated that for each birth cohort vaccinated with routine immunizations (including DTaP [diphtheria, tetanus, acellular pertussis], Td [tetanus, diphtheria], Hib [Haemophilus]

influenzae type B], polio, MMR [measles, mumps, rubella], hepatitis B, and varicella vaccines), 33,000 lives will be saved, 14 million cases of disease will be prevented, and \$9.9 billion in direct health care costs will be saved.5 While immunization rates have been increasing in the adolescent population, they are still below the administration rates seen in early childhood (Figure 3).1,3 Many barriers to vaccination and preventive health service visits have been identified, including (but not limited to) cost, accessibility, perceived lack of utility, and a lack of community resources.3 In the present review, we summarize current recommendations for adolescent vaccines, the infections they prevent, and their formulations; contraindications to administration; vaccination rates; and the most commonly reported adverse events (Table).

Meningococcal Conjugate Vaccine

Formulations: Menactra (MCV4): approved for patients aged 9 months to 55 years; Menveo (MenACWY-CRM): approved for patients aged 2 months to 55 years

The meningococcal conjugate vaccine is administered to prevent invasive meningococcal infections caused by *N meningitidis*, a gram-negative diplococcus. All vaccine formulations currently protect against 4 of the 5 meningococcal serogroups (A, C, Y, and W-135); no vaccine is currently licensed to protect against the B serogroup, which is responsible for more than 50% of cases and deaths. The most common presentations of infection with this bacteria are meningitis and sepsis, commonly occurring in (but not limited to) students living in dormitories, persons residing in military bar-

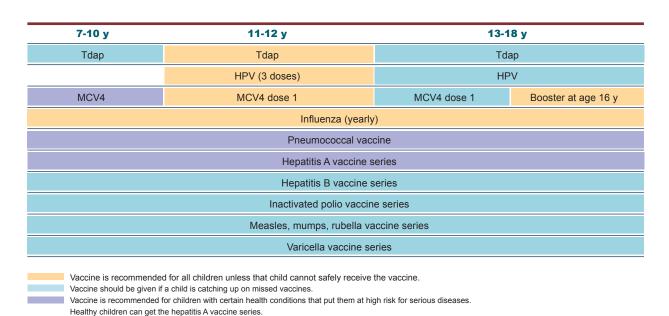


Figure 1.Recommended immunizations for children aged 7 to 18 years. Adapted from the Centers for Disease Control and Prevention.

Figure 2. Recommended immunization schedule for persons aged 0 to 18 years. Adapted from the Advisory Committee on Immunization Practices' recommended immunization schedule for persons aged 0 through 18 years-United States, 2013.1

					Age, mo								Age, y	٨		
Vaccine	Birth	-	7	4	9	6	12	15	18	19-23	2-3	4-6	7-10	11-12	13-15	16-18
Hepatitis B	Dose 1	DC	Dose 2				Dose 3									
Rotavirus			Dose 1	Dose 2	Dose 3ª											
DTaP, age <7 y			Dose 1	Dose 2	Dose 3			Dose 4	4 6			Dose 5				
Tdap, age ≽7 y														1 dose		
Hib			Dose 1	Dose 2	Dose 3 ^b		Dose 3 or 4 ^b	- 4 ^b								
PCV13			Dose 1	Dose 2	Dose 3		Dose 4									
PPSV23																
Inactivated poliovirus	SI		Dose 1	Dose 2			Dose 3					Dose 4				
Influenza						Anr	Annual vaccination (IIV only)	yluo VII) no	()			Annua	l vaccinatic	Annual vaccination (IIV or LAIV)	(VI	
MMR							Dose 1	_				Dose 2				
Varicella							Dose 1	_				Dose 2				
Hepatitis A								2-dose series ^c	series							
Human papillomavirus⁴	'us ^d													3-dose series		
Meningococcale booster	oster													Dose 1		booster

Range of recommended ages for catch-up immunization

Range of recommended ages for all children

Range of recommended ages for certain high-risk groups Not routinely recommended If RV-1 (Rotarix) is used, administer a 2-dose series at ages 2 and 4 months. If RV-5 (RotaTeq) is used, administer a 3-dose series at ages 2, 4, and 6 months. If PRP-OMP (PedvaxHib or Comvax) is administered at 2 and 4 months of age, a dose at age 6 months is not indicated. Hiberiz (PRP-T) should only be used

HPV2 (Cervarix) should be used on females only. HPV4 (Gardasil) may be used in both males and females. The second dose should be administered for the booster (final) dose in children aged 12 months through 4 years who have received at least 1 dose of Haemophilus influenzae type b (Hib) The 2 doses should be separated by 6 to 18 months.

Minimum ages for the meningococcal vaccines are as follows: 6 weeks for Hib-MenCY, 9 months for Menactra (MCV4-D), and 2 years for Menveo (MCV4-CRM). 1 to 2 months after the first dose, and the third dose should be administered 6 months after the first dose

MMR, measles, mumps, rubella; PCV13, pneumococal conjugate; PPSV23, pneumococcal polysaccharide; Tdap, tetanus, diphtheria, and acellular pertussis. Abbreviations: DTaP, tetanus, diphtheria, and acellular pertussis; IIV, inactivated influenza vaccine; LAIV, live, attenuated influenza vaccine;

racks, and children with asplenia.⁷ Some common symptoms include nausea, vomiting, sensitivity to light, confusion, and sleepiness.⁸ From 2006 to 2010, an average of 1051 cases of new laboratory-confirmed meningococcal disease were reported.⁹

The preferred age at vaccination is 11 to 12 years, with a booster dose at age 16 years because of waning immunity in most adolescents within 5 years of initial inoculation.7 Patients who receive this vaccine for the first time between ages 13 to 15 years require the 1-time booster dose between ages 16 and 18 years.7 Contraindications to vaccination include a history of a serious allergic reaction (eg, anaphylaxis) after a previous dose of meningococcal vaccine or to a meningococcal vaccine component. Precautions are taken when there is accompanying moderate or severe acute illness with or without fever.7 Reported adverse events include redness or pain at the injection site and mild fever.7 Serious allergic reactions are rare. Immunization rates for adolescents aged 13 to 17 years increased from 70.5% in 2011 to 74.0% in 2012.10

Tetanus, Diphtheria, and Pertussis Vaccine

Formulations: Boostrix, Adacel

The Tdap (tetanus, diphtheria, and acellular pertussis) vaccine is administered to prevent tetanus caused by Clostridium tetani, a gram-positive bacillus; diphtheria caused by Corynebacterium diphtheria, a grampositive rod; and pertussis (whooping cough) caused by B pertussis, a gram-

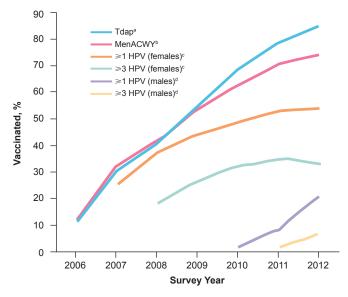


Figure 3.
Estimated vaccination coverage with selected vaccines and doses among adolescents aged 13-17 years, by survey year, in the United States during 2006-2012. ^a ≥1 dose tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccine on or after age 10 years. ^b ≥1 dose meningococcal conjugate (MenACWY) vaccine. ^c Human papillomavirus (HPV) vaccine, either bivalent or quadrivalent, among females (the Advisory Committee on Immunization Practices [ACIP] recommends either bivalent or quadrivalent vaccine for females). ^d HPV vaccine, either bivalent or quadrivalent, among males (the ACIP recommends the quadrivalent vaccine for males; however, some males might have received bivalent vaccine). Adapted from the Centers for Disease Control and Prevention. ¹⁰

negative coccobacillus. The most common presentations of infection with C tetani include painful spasms and stiffness of all muscles in the body, including a phenomenon known as "lock-jaw."11 Common presentations of patients with C diphtheria infections include weakness, sore throat, low-grade fever, swollen lymph nodes, and a pharyngeal pseudomembrane with upper respiratory infection.12 Patients infected with B pertussis commonly present with spells of violent coughing, which can cause vomiting, difficulty breathing, and disturbed sleep.11 There were 4000 confirmed and probable cases of pertussis reported among adolescents aged 11 to 19 years in 2011.20

The preferred age at vaccination is 11 to 12 years, with a tetanus and diphtheria toxoids (Td) booster administered every 10 years. 11 Of note, for adolescents who inadvertently receive a pediatric DTaP vaccine, this dose is considered sufficient as a Tdap booster.1 Contraindications to vaccination include a history of a serious allergic reaction (eg, anaphylaxis) after a previous dose and a history of encephalopathy not attributable to another identifiable cause within 7 days of receipt of the Tdap vaccine.¹¹ Precautions are taken when there is accompanying moderate or severe acute illness with or without fever; Guillain-Barré syndrome (GBS) within 6 weeks after a previous dose of tetanus toxoid-containing vaccine; history of an Arthus-type reaction after a dose of tetanus- or diphtheria toxoid–containing vaccine; or unstabilized progressive or unstable neurologic disorders, uncontrolled seizures, or progressive encephalopathy. Reported adverse events include redness or pain at the injection site, mild fever, headache, tiredness, nausea, vomiting, diarrhea, chills, body aches, and sore joints. Serious allergic reactions are rare. The 2012 Tdap immunization rate was 84.6% for patients aged 10 years or older (increased from 78.2% in 2011).

Human Papillomavirus Vaccine

Formulations: Gardasil (quadrivalent HPV): approved for male and female patients; Cervarix (bivalent HPV): approved for female patients only

The HPV vaccine is administered to prevent infection caused by HPV, a DNA virus. Vaccination against HPV began relatively recently: the US Food and Drug Administration approved the quadrivalent HPV vaccine in June 200613 for females and December 2010 for males¹⁴ and approved the bivalent HPV vaccine in October 2009 for females.15 The most common presentations of this disease include genital warts, but HPV can also cause cervical, vaginal, and vulvar cancers in women and anal and oropharyngeal cancers in both men and women. 16,17 More than 40 types of HPV are believed to cause disease in humans, with more than a dozen types that have been shown to be oncogenic, specifically types 16 and 18 of HPV.18

Uncertainty remains about the differential benefit of the 2 vaccines that are currently available. 19 In 2013, an estimated 12,340 women were diagnosed as having cervical cancer. 20

The preferred age at delivery is 11 to 12 years for the first dose, with administration of a second dose 1 to 2 months after dose 1 and a third dose at least 6 months after dose 1.16,17 Contraindications to vaccination include a history of a serious allergic reaction (eg, anaphylaxis) after a previous dose or to a component of the HPV vaccine. Precautions are taken when there is accompanying moderate or severe acute illness with or without fever. Reported adverse events include redness or pain at the injection site, mild fever, headache, and fainting. 16,17 To prevent fainting episodes, patients are advised to sit or lie down for 15 minutes after vaccination. 16,17 Serious allergic reactions are rare. 16,17 In 2012, immunization rates (3 doses administered) were 33.4% for females and 6.8% for males aged 13 to 17 years.10 Although the vaccination rate for males is much lower than for females (likely due in part to the more recent approval of the HPV vaccine for males), this rate is an increase from the 1.3% vaccination rate in males in 2011.10

Influenza Vaccine

Formulations: Inactivated

vaccine (trivalent and quadrivalent): given via intramuscular route; Live, attenuated vaccine (quadrivalent): given via nasal spray

The influenza vaccine is administered to prevent infection caused by the in-

fluenza virus, an RNA virus. The most common presentations of this disease include sudden high fever or chills, sore throat, muscle aches, fatigue, cough, headache, and rhinorrhea.^{21,22}

This vaccination is recommended on an annual basis for persons aged 6 months or older, with 2 doses recommended for individuals who are receiving the vaccine for the first time and who are younger than 9 years.21,22 This vaccination is especially important for children with comorbid medical conditions to decrease the risk of serious complications from infection with influenza. Contraindications to vaccination include a history of a serious allergic reaction (eg, anaphylaxis) after a previous dose or to a component of the influenza vaccine or a history of GBS.21,22

In general, quadrivalent formulations provide more immunogenic coverage than the trivalent preparations. The live, attenuated formulation has been shown to elicit a long-lasting, broader immune (humoral and cellular) response in children.23 However, precautions are taken when there is accompanying moderate or severe acute illness with or without fever. The live, attenuated influenza nasal spray vaccine is not recommended or licensed for use in patients who are pregnant, immunocompromised, younger than 2 years, or older than 50 years.22 The live, attenuated formulation is also not recommended or licensed for use in people with asthma, individuals with a history of egg allergy, children on long-term aspirin therapy, or children and adults who have chronic pulmonary, cardio-

Table.

Recommended Adolescent Vaccination Information

Vaccine	Formulations	Preferred Age at Delivery	Contraindications	Most Commonly Reported Adverse Events
Meningococcal conjugate	Menactra (MCV4) Menveo (MenACWY-CRM)	11-12 y, booster at 16 y	History of serious allergic reaction (anaphylaxis) to meningococcal vaccine component	Redness or pain at injection site Mild fever
Tdap (tetanus, diphtheria, acellular pertussis)	Boostrix (Tdap) Adacel (Tdap)	11-12 y, Td booster every 10 y	History of serious allergic reaction (anaphylaxis) to previous dose of tetanus- toxoid vaccine; Encephalopathy within 7 d of prior Tdap	Redness or pain at injection site Mild fever Headache, tiredness, chills Nausea, vomiting, diarrhea Body aches or sore joints
Human papilloma- virus (HPV)	Gardasil (quadrivalent) Cervarix (bivalent)	Dose 1: 11-12 y Dose 2: 1-2 mo after dose 1 Dose 3: 6 mo after dose 1	History of serious allergic reaction (anaphylaxis) to HPV vaccine component	Fainting Redness or pain at injection site Mild fever, headache
Influenza	Inactivated (intramuscular) Live, attenuated (intranasal)	≽6 mo, annual dosing	History of serious allergic reaction (anaphylaxis) to influenza vaccine component History of Guillain-Barré syndrome	Redness or pain at injection site Mild fever Headache, fatigue, pruritus

vascular (except isolated hypertension), renal, hepatic, neurologic, neuromuscular, hematologic, or metabolic disorders.²² Reported adverse events for the influenza vaccines include redness or pain at the injection site, mild fever, aches, fatigue, headache, and itching.^{21,22} Serious allergic reactions and GBS are rare.^{21,22} During the 2011-2012 influenza season, the vaccination rate for individuals aged 5 to 17 years was 45.1%.²⁴

Additional Vaccines

In addition to the vaccines that are recommended at the adolescent health visit (ie, HPV, Tdap, meningococcal conjugate vaccine, and annual influenza), current guidelines recommend vaccination against the diseases of measles, mumps, rubella, varicella, hepatitis B, and inactivated polio for those who have not previously received these vaccines. Additionally, the hepatitis A and pneumococcal vaccines are recommended for adolescents with certain health conditions that put them at high risk for serious diseases (Figure 1).1 In 2012, the percentage of children aged 13 to 17 years who received the recommended 2 doses of the measles, mumps, rubella vaccine was 91.4%:10 the percentage of children who received the recommended 3 doses of the hepatitis B vaccine was 92.8%;10 and the percentage of children who received the recommended 2 doses of the varicella vaccine (or had history of varicella disease) was 82.6%.10

Future Vaccines

Vaccine development efforts are underway for the prevention of diseases such as human immunodeficiency virus, tuberculosis, herpes simplex, hepatitis C, and cytomegalovirus. ²⁵ As technology advances, so do the opportunities to vaccinate against an increasing number of diseases. In doing so, some of these vaccines may be administered during the adolescent years, further validating the importance of routine health supervision visits for preventive health.

Conclusion

Vaccination is a safe and effective tool in the prevention of select infectious diseases and remains a vital component of preventive health services administered to the adolescent population. With continued research and development toward novel vaccinations, there is a promising outlook for additional disease prevention. There is room for improvement in both access to, and opportunity for, adolescent vaccinations. Strategies should be implemented to maintain cognizance of important vaccination opportunities at health supervision and other health visits, including select ill-child visits.

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