INFLUENZA — The effectiveness of the seasonal vaccine in preventing influenza in healthy adults varies annually depending on the match between the vaccine components and circulating strains. It is highest when the match is close (generally 50-80% effective in young adults; lower in the elderly).

VACCINE PREPARATIONS

Live-attenuated vaccines use a weakened form of the pathogen, which replicates after administration to induce an immune response. Compared to inactivated vaccines, live-attenuated vaccines tend to have higher rates of adverse effects, particularly fever.

Inactivated vaccines are prepared from whole bacteria or virus, or a fractional antigenic component of one. Fractional vaccines are usually either protein- or polysaccharide-based. Protein-based vaccines typically include subunits of microbiologic protein or inactivated bacterial toxins (toxoids). Polysaccharide-based vaccines are generally less immunogenic than protein-based vaccines; they may be conjugated to a protein to increase the immune response.

VACCINES

INFLUENZA — The effectiveness of the seasonal vaccine in preventing influenza in healthy adults varies annually depending on the match between the vaccine components and circulating strains. It is highest when the match is close (generally 50-80% effective in young adults; lower in the elderly). Trivalent influenza vaccines contain two influenza A strains and one influenza B strain; while quadrivalent vaccines contain an additional influenza B strain; all of the strains are selected annually based on global surveillance data reported by the CDC.

Recommendations for Use — Annual vaccination is recommended for all adults without a specific contraindication, including pregnant women. Vaccination against influenza is especially important for healthcare workers and close contacts of high-risk persons. Serum antibodies reach maximal levels in most adults about 2 weeks after vaccination and generally persist for at least 6 to 8 months. The vaccine should be offered from the time it becomes available in late summer until the end of the influenza season in May; if possible, it should be given by October.

Both inactivated and live-attenuated influenza vaccines are available in the US. The inactivated vaccine may be more effective than the live-attenuated vaccine in previously immunized adults. The live-attenuated intranasal vaccine (FluMist Quadrivalent) can be used in healthy, non-pregnant persons <50 years old. It should
not be used in patients who are immunocompromised and is not recommended for persons with asthma, reactive airway disease, or chronic cardiovascular, pulmonary, renal, or metabolic disease.

The high-dose trivalent inactivated vaccine (Fluzone High-Dose), which contains 60 mcg of hemagglutinin antigen from each strain compared to 15 mcg in the conventional vaccine, produces significantly higher antibody levels than the standard-dose vaccine in persons ≥65 years old.6,5 In an unpublished study in >30,000 patients ≥65 years old, Fluzone High-Dose was 24% more effective than the standard-dose vaccine in preventing laboratory-confirmed influenza over two influenza seasons.7

A retrospective cohort study found that vaccination of pregnant women with the inactivated vaccine reduced the risk of preterm delivery and small-for-gestational-age births during the influenza season.8

### Table 1. Vaccines for Adults

<table>
<thead>
<tr>
<th>Vaccines</th>
<th>Dose/Schedule</th>
<th>Recommendation</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Influenza</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trivalent (Inactivated)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Afluria (bioCSL)</td>
<td>0.5 mL IM/1 dose per year</td>
<td>Annual dose recommended for all adults</td>
<td>$10.90</td>
</tr>
<tr>
<td>Fluarix (GSK)</td>
<td></td>
<td></td>
<td>9.90</td>
</tr>
<tr>
<td>Flucelvax (Novartis)</td>
<td></td>
<td></td>
<td>19.10</td>
</tr>
<tr>
<td>FluLaval (GSK)</td>
<td></td>
<td></td>
<td>7.70</td>
</tr>
<tr>
<td>Fluvirin (Novartis)</td>
<td></td>
<td></td>
<td>14.20</td>
</tr>
<tr>
<td>Fluzone (Sanofi Pasteur)</td>
<td></td>
<td></td>
<td>11.60</td>
</tr>
<tr>
<td>Fluvax (Pfizer)</td>
<td></td>
<td></td>
<td>32.80</td>
</tr>
<tr>
<td>Fluzone High-Dose (Sanofi Pasteur)</td>
<td>0.1 mL intradermal/1 dose per year</td>
<td>Annual dose recommended for all adults</td>
<td>27.30</td>
</tr>
<tr>
<td>Flu Vaccine (Novartis)</td>
<td>0.1 mL intradermal/1 dose per year</td>
<td>Annual dose recommended for all adults</td>
<td>16.00</td>
</tr>
<tr>
<td><strong>Quadrivalent (Inactivated)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluarix Quadrivalent (GSK)</td>
<td>0.5 mL IM/1 dose per year</td>
<td>Annual dose recommended for all adults</td>
<td>15.90</td>
</tr>
<tr>
<td>Fluarix Quadrivalent (GSK)</td>
<td>0.5 mL IM/1 dose per year</td>
<td>Annual dose recommended for all adults</td>
<td>14.90</td>
</tr>
<tr>
<td>Fluzone Quadrivalent (Sanofi Pasteur)</td>
<td>0.5 mL IM/1 dose per year</td>
<td>Annual dose recommended for all adults</td>
<td>17.10</td>
</tr>
<tr>
<td><strong>Quadrivalent (Live-attenuated)</strong></td>
<td>0.2 mL intranasal/1 dose per year</td>
<td>Annual dose recommended for all adults</td>
<td>22.70</td>
</tr>
<tr>
<td>FluMist Quadrivalent (Medimmune)</td>
<td>0.2 mL intranasal/1 dose per year</td>
<td>Annual dose recommended for all adults</td>
<td>22.70</td>
</tr>
<tr>
<td><strong>Tetanus, Diphtheria (Td)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tetanus and Diphtheria Toxoids</td>
<td>0.5 mL IM/1 dose per year</td>
<td>Primary series recommended for all adults without history of vaccination</td>
<td>18.00</td>
</tr>
<tr>
<td>Adsorbed (MassBiologics/Merck)</td>
<td>(0, 1, 2, and 6-12 mos)</td>
<td>1 booster q10 years</td>
<td>21.70</td>
</tr>
<tr>
<td>Tenivac (Sanofi Pasteur)</td>
<td>0.5 mL IM/1 dose per year</td>
<td>Single dose recommended for all adults, regardless of interval since last Td</td>
<td>41.10</td>
</tr>
<tr>
<td><strong>Human Papillomavirus (HPV)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cervarix (GSK)</td>
<td>0.5 mL IM/1 dose per year</td>
<td>Recommended for all previously unvaccinated females 13-26 years old, males 13-21 years old, and males 13-26 years old with risk factors; men should receive Gardasil</td>
<td>128.80</td>
</tr>
<tr>
<td>Gardasil (Merck)</td>
<td>0.5 mL IM/1 dose per year</td>
<td>Recommended for all previously unvaccinated females 13-26 years old, males 13-21 years old, and males 13-26 years old with risk factors; men should receive Gardasil</td>
<td>141.40</td>
</tr>
<tr>
<td><strong>Varicella</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Varivax (Merck)</td>
<td>0.5 mL SC/1 dose per year</td>
<td>Recommended for all adults born in or after 1980 without evidence of immunity</td>
<td>94.10</td>
</tr>
<tr>
<td><strong>Zoster</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zostavax (Merck)</td>
<td>0.65 mL SC/1 dose</td>
<td>Recommended for all adults ≥60 years old, including those with a previous episode of zoster (FDA-approved for persons ≥50 years old)</td>
<td>165.70</td>
</tr>
</tbody>
</table>

1. See Table 2 for vaccination of special populations. See text for detailed information on indications, contraindications, and risk factors.
4. Recombinant hemagglutinin vaccine; does not contain egg protein. Not FDA-approved for adults >49 years old.
5. Price according to manufacturer.
6. FDA-approved for persons ≥65 years old. Contains 60 mcg of hemagglutinin antigen from each strain compared to 15 mcg from each strain in the conventional vaccine.
7. FDA-approved for adults ≥64 years old. Contains 9 mcg of hemagglutinin antigen from each strain.
9. Inactivated vaccine.
10. Although Adacel is not FDA approved for persons ≥65 years old, the ACIP recommends use of either Boostrix or Adacel in persons ≥65 years old.
11. Minimum interval between doses 1 and 2 is 3 weeks; between doses 2 and 3 is 12 weeks, and between doses 1 and 3 is 24 weeks.
12. Live-attenuated vaccine.
Studies have also found that vaccinating women during pregnancy reduces proven influenza illness in infants <6 months old. Pregnant women should not receive the live-attenuated influenza vaccine.

**Adverse Effects** – Except for soreness at the injection site, adverse reactions to inactivated influenza vaccine are uncommon. In clinical trials, Fluzone High-Dose and Fluzone Intradermal have caused more injection-site reactions than standard vaccines. Fever, myalgia, and malaise can occur and have been more common with the high-dose vaccine. Influenza vaccination has been associated with Guillain-Barré syndrome, but the absolute risk is very low (1-2 cases per million persons vaccinated) and influenza infection itself has also been associated with Guillain-Barré syndrome.

The live-attenuated intranasal vaccine is generally well tolerated, but can cause rhinorrhea, nasal congestion, and sore throat. After receiving the live-virus vaccine, healthcare workers and family members should avoid close contact with severely immunocompromised patients in

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**Table 1. Vaccines for Adults (continued)**

<table>
<thead>
<tr>
<th>Vaccines</th>
<th>Dose/Schedule</th>
<th>Recommendation¹</th>
<th>Cost²</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measles, Mumps, Rubella (MMR)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M-M-R II (Merck)¹¹</td>
<td>0.5 mL SC/1-2 doses¹³</td>
<td>Recommended for all adults born during or after 1957 without evidence of immunity</td>
<td>56.10</td>
</tr>
<tr>
<td><strong>Pneumococcal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pneumovax 23 (PPSV23; Merck)³</td>
<td>0.5 mL IM or SC 1-2 doses¹⁴</td>
<td>PPSV23 is recommended for all adults ≥65 years old (1 dose) and for those &lt;65 years old with specific risk factors (1-2 doses); PCV13 is recommended for adults ≥19 years old with specific risk factors (FDA-approved for adults ≥50 years old)¹⁵</td>
<td>68.30</td>
</tr>
<tr>
<td>Prevnar 13 (PCV13; Pfizer)³</td>
<td>0.5 mL IM/1 dose</td>
<td></td>
<td>128.20</td>
</tr>
<tr>
<td><strong>Hepatitis A</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Havrix (GSK)³</td>
<td>1 mL IM /2 doses (0 and 6-12 mos)</td>
<td>Recommended for all unvaccinated adults with medical, occupational, or behavioral risk factors</td>
<td>63.10</td>
</tr>
<tr>
<td>Vaqta (Merck)³</td>
<td>1 mL IM/2 doses (0 and 6-12 mos)</td>
<td></td>
<td>62.50</td>
</tr>
<tr>
<td><strong>Hepatitis B</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engerix-B (GSK)³</td>
<td>1 mL IM/3 doses (0, 1, and 6 mos)¹⁶,¹⁷,¹⁸</td>
<td>Recommended for all unvaccinated adults with medical, occupational or behavioral risk factors (FDA-approved for persons ≥20 years old)</td>
<td>52.50</td>
</tr>
<tr>
<td>Recombivax HB (Merck)³</td>
<td>1 mL IM/3 doses (0, 1, and 6 mos)¹⁶,¹⁸</td>
<td></td>
<td>60.00</td>
</tr>
<tr>
<td><strong>Hepatitis A/B</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Twinrix (GSK)³</td>
<td>1 mL IM/3 doses (0, 1, and 6 mos)¹⁹</td>
<td>Recommended for all adults who require both hepatitis A and B vaccine</td>
<td>92.50</td>
</tr>
<tr>
<td>Meningococcal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conjugated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Menveo (Novartis)³¹,²⁰</td>
<td>0.5 mL IM/1-2 doses²¹,²²</td>
<td>Recommended for unvaccinated adults with specific risk factors; Menveo and Menactra are FDA-approved for adults ≥55 years old and are preferred for this age group; adults ≥56 years old should receive Menomune, unless they will need multiple doses</td>
<td>117.40</td>
</tr>
<tr>
<td>Menactra (Sanofi Pasteur)³¹,²⁰</td>
<td>0.5 mL IM/1-2 doses²¹,²²</td>
<td></td>
<td>112.90</td>
</tr>
<tr>
<td>Unconjugated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Menomune (Sanofi Pasteur)³¹,²⁰</td>
<td>0.5 mL SC/1 dose²¹,²²</td>
<td>Recommended for unvaccinated adults with specific risk factors; Menomune is FDA-approved for ages ≥19 years old, 1 dose, and ≥50 years old</td>
<td>116.60³</td>
</tr>
<tr>
<td>Haemophilus influenzae type b (Hib)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ActHIB (Sanofi Pasteur)³</td>
<td>0.5 mL IM/1 or 3 doses²³</td>
<td>Recommended only for a small number of unvaccinated adults with specific risk factors; not FDA-approved for use in adults</td>
<td>26.20</td>
</tr>
<tr>
<td>PediaVaxHIB (Merck)³</td>
<td></td>
<td></td>
<td>22.80</td>
</tr>
</tbody>
</table>

13. One or 2 doses for no evidence of immunity to measles and mumps (second dose must be administered at least 28 days after the first) and 1 dose for no evidence of immunity to rubella.
14. One-time revaccination after 5 years for adults <65 years old with chronic renal failure or nephrotic syndrome, asplenia, or immunocompromising conditions. One additional dose at or after age 65 (5 years after previous dose) for persons who received 1 or 2 doses before age 65.
15. When both vaccines are indicated, PCV13 should be given first (See page 45 for information on indications and timing).
16. When doses 1 and 2 are indicated, PCV13 should be given first (See page 45 for information on indications and timing).
17. One dose is recommended for all others.
18. Alternative vaccination schedules (0, 1, and 4 months or 0, 2, and 4 months) are also recommended by ACIP. Minimum interval between doses 1 and 2 is 4 weeks, between doses 2 and 3 is 8 weeks, and between doses 1 and 3 is 16 weeks.
19. Minimum interval between doses 1 and 2 is 4 weeks and between doses 2 and 3 is 5 months. A 4-dose accelerated schedule at 0, 7, 21-30 days, and 12 months is also FDA-approved.
21. Two doses of Menactra or Menveo given 8-12 weeks apart are recommended for all adults with asplenia or persistent complement component deficiencies. One dose is recommended for all others.
22. One dose is recommended for those previously vaccinated who remain at high risk.
23. One dose for immunized asplenic patients and those undergoing elective splenectomy. Three doses (at least 4 weeks apart) for all recipients of hematopoietic stem cell transplants (beginning 6-12 months after transplant), even if previously vaccinated.
protected environments for 7 days because of the theoretical risk of transmission of vaccine-strain virus.

**Allergy** – A history of a severe allergic reaction to any influenza vaccine is a contraindication to vaccination. Persons who report a history of allergy (of any severity) related to egg exposure can be vaccinated with FluBlok, a trivalent inactivated vaccine that is not produced in eggs. Persons who experienced only hives after egg exposure can also receive other inactivated influenza vaccines, but they should be observed for at least 30 minutes following vaccine administration for signs of an allergic reaction.

**TETANUS, DIPHTHERIA AND PERTUSSIS** — A vaccine containing inactivated adsorbed (aluminum-salt-precipitated) tetanus and diphtheria toxoids (Td) has been the standard booster vaccine for adults for many years. Adults were not re-immunized against pertussis because of concerns about reactions to the whole cell vaccine, but a gradual and sustained increase in pertussis incidence has been observed, with many cases occurring in adults whom vaccine-induced immunity has waned over time. Pertussis infection in adults can be associated with severe complications, including stroke and pneumothorax caused by coughing paroxysms. Waning immunity in adults has led to transmission of pertussis to unand under-immunized infants, with some deaths. Two vaccines (Adacel, Boostrix) containing protein components of acellular pertussis combined with diphtheria and tetanus toxoids (Tdap) are available as a booster for adults.

**Recommendations for Use** — Adults with an uncertain history of primary vaccination should receive 3 doses of a tetanus and diphtheria toxoids vaccine, one of which (preferably the first) should be Tdap. The first 2 doses should be administered at least 4 weeks apart and the third dose 6-12 months after the second. Adults who have completed a primary childhood series and have not received a dose of Tdap during adolescence, particularly those who have or anticipate having contact with an infant <12 months old, should be given a single dose to protect against pertussis, regardless of the interval since their last tetanus toxoid injection. Adults who require tetanus toxoid-containing vaccine as a booster (recommended every 10 years) or as a part of wound management should be given Tdap instead of Td if they have not previously received Tdap.

**Pregnant women** should receive Tdap during each pregnancy, regardless of the interval since prior Td or Tdap vaccination, to protect the newborn against pertussis. They should preferably receive it during the third trimester (27-36 weeks) so that the highest possible concentration of maternal antibodies can be transferred closer to birth. If Tdap is not administered during pregnancy, it should be given immediately postpartum. Pregnant women with an uncertain or incomplete history of primary vaccination should be given 3 doses of a tetanus and diphtheria toxoids vaccine according to the regular adult schedule; one of the doses should be Tdap (preferably administered during the third trimester).

**Adverse Effects** – Local reactions around the injection site, such as erythema and induration, are common, but are usually self-limited. Arthus-type reactions with extensive painful swelling can occur rarely in adults with a history of repeated vaccinations. Fever and injection-site pain have been more frequent with Tdap than with Td.

**HUMAN PAPILLOMAVIRUS (HPV)** — HPV is a common sexually transmitted infection often acquired soon after initiation of sexual activity. Although most HPV infections clear spontaneously without clinical sequelae, persistent infection with an oncogenic HPV type can cause abnormalities in cervical epithelium that may progress to cancer. Genital HPV types 16 and 18 cause more than 70% of cervical cancers and about 80% of anal cancers; types 6 and 11 cause 90% of genital warts. Whether genital types of HPV are associated with nongenital cancers is less well established, but they may play a role in some oral cavity and pharyngeal cancers.

Two inactivated recombinant human papillomavirus-like particle vaccines are approved by the FDA. A bivalent vaccine (Cervarix) is approved for use in girls and young women to prevent diseases associated with oncogenic HPV types 16 and 18. A quadrivalent vaccine (Gardasil) is approved for use in both sexes to prevent diseases associated with HPV types 6, 11, 16, and 18. The quadrivalent vaccine has been shown to reduce the incidence of genital warts in women and the rate of anal intraepithelial neoplasia among men who have sex with men. The bivalent vaccine can induce higher antibody levels than the quadrivalent vaccine for HPV types 16 and 18; whether these higher levels lead to greater long-term protection is unknown.

**Recommendations for Use** — Routine HPV vaccination is recommended for girls (with Cervarix or Gardasil) and boys (with Gardasil) 11-12 years old, administered in 3 doses (0, 1-2, and 6 months). Vaccination is recommended for young women 13-26 years old and for young men 13-21 years old who have not been vaccinated previously. Men who have sex with men and immunocompromised men are at higher risk for infection and should be vaccinated through age 26. Vaccination may be considered for heterosexual men 22-26 years old. Although the vaccine should ideally
be administered before the onset of sexual activity, patients who have already been exposed to HPV or diagnosed with HPV (based on an abnormal Pap smear or presence of genital warts) should also be vaccinated because they may not have been exposed to all the HPV types included in the vaccine. The duration of immunity is not known, but it appears to last at least 8-10 years; booster doses are not currently recommended.

HPV vaccine has not been recommended for pregnant women due to limited data, but no adverse outcomes have been reported among women who became pregnant after receiving the vaccine.20

Adverse Effects – Injection-site reactions such as pain, swelling, and erythema can occur, but discontinuation of the vaccine series has been uncommon. Syncope after vaccination has occurred; patients should be seated and observed for 15 minutes after the injection.

VARICELLA — Universal childhood vaccination against varicella, introduced in the US in 1995, has resulted in a sharp decline in the incidence of varicella in both children and adults. Primary varicella infection is much more severe in adults than in children.

Recommendations for Use – Persons born in the US before 1980 are considered immune to varicella, except for healthcare workers and pregnant women, who should have other evidence of immunity. Evidence of immunity to varicella is demonstrated by: a history of typical varicella diagnosed by a healthcare provider, laboratory evidence of immunity (not always reliable), documentation of vaccination, or healthcare provider-

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**Table 2. Adult Vaccines for Special Populations**

<table>
<thead>
<tr>
<th>Risk Groups</th>
<th>HPV</th>
<th>Td/ Tdap</th>
<th>Influenza</th>
<th>Pneumococcal</th>
<th>MMR</th>
<th>Variocella</th>
<th>Zoster</th>
<th>Hep B</th>
<th>Hep A</th>
<th>Meningococcal</th>
<th>Hib</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pregnancy</td>
<td>NR</td>
<td>✓</td>
<td>✓</td>
<td>RF</td>
<td>C</td>
<td>✓</td>
<td>C</td>
<td>RF</td>
<td>RF</td>
<td>RF</td>
<td>NR</td>
</tr>
<tr>
<td>Immunocompromising conditions (except HIV)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>RF</td>
<td>RF</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Diabetes, chronic cardiac or pulmonary disease, or chronic alcoholism</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>RF</td>
<td>RF</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Asplenia (including persistent complement deficiencies)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>RF</td>
<td>RF</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Kidney disease (including hemodialysis)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td>Chronic liver disease</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>RF</td>
<td>RF</td>
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<td>✓</td>
</tr>
<tr>
<td>HIV</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>RF</td>
<td>RF</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CD4 count &lt;200 cells/mcL</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>RF</td>
<td>RF</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CD4 count &gt;200 cells/mcL</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>RF</td>
<td>RF</td>
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<tr>
<td>Healthcare workers</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>RF</td>
<td>RF</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Men who have sex with men</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>RF</td>
<td>RF</td>
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</tr>
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* See Table 1 for age restrictions

✓ = Recommended; RF = Recommended if another risk factor is present; = Contraindicated; NR = No recommendation
**Adult Immunization**

diagnosed zoster. Newly arrived adult immigrants from tropical countries may be susceptible to varicella. All adults without evidence of immunity should be vaccinated with two doses of vaccine, separated by at least 4 weeks. Non-immune **pregnant women** should receive the first dose postpartum before hospital discharge. Immunity after vaccination is probably permanent in the majority of vaccinees.

**Adverse Effects** – Injection-site reactions such as soreness, erythema, and swelling are common in adults. Other adverse effects include fever and varicella-like rash (injection site or generalized). Spread of vaccine virus from healthy vaccinees who develop a varicella-like rash to susceptible contacts has been reported, but is rare. Recipients who have a vaccine-related rash should avoid contact with susceptible individuals who are at high risk of complications of varicella, such as immunocompromised persons, pregnant women, and neonates born to non-immune mothers.

**Contraindications** – Because it is a live vaccine, varicella vaccine is contraindicated in pregnant women and in persons with severe immunodeficiency. It should not be given to patients with a history of anaphylaxis caused by neomycin.

**ZOSTER** — Following primary infection, varicella-zoster virus (VZV) persists in a latent form in sensory ganglia; VZV-specific cell-mediated immunity (CMI) prevents latent virus from reactivating and multiplying to cause herpes zoster. When CMI falls below a critical threshold, as it can in older persons and immunocompromised patients, latent VZV can reactivate and cause herpes zoster (“shingles”). A live-attenuated vaccine (Zostavax) protects against herpes zoster and postherpetic neuralgia.21,22

**Recommendations for Use** – A single dose of Zostavax is recommended for all immunocompetent persons ≥60 years old. The vaccine has been shown to be effective in persons ≥50 years old.23 Vaccination might be considered for adults 50-59 years old with comorbid conditions that could reduce their ability to tolerate herpes zoster or postherpetic neuralgia symptoms.24 The duration of efficacy of the vaccine has not been established, but there is some evidence that efficacy persists through year 5 after vaccination in persons ≥60 years old.25

**Contraindications** – Because it is a live vaccine, Zostavax is contraindicated in pregnant women and in persons with severe immunodeficiency. It should not be given to patients with a history of anaphylaxis caused by neomycin.

**MEASLES, MUMPS, RUBELLA (MMR)** — Routine vaccination of children with MMR vaccine has eliminated measles and rubella, and almost eliminated mumps, in the US. Recent increases in measles cases in Europe and Southeast Asia have led to an increasing number of import-associated measles cases in the US, mostly in unvaccinated persons.26 Sporadic mumps outbreaks also continue to occur.

The MMR vaccine contains live-attenuated measles virus and mumps virus, both derived from chick embryo cell culture, and rubella virus derived from human diploid cell culture.

**Recommendations for Use** – Adults born in the US before 1957 (1970 in Canada) can be considered immune to measles, mumps, and rubella. All other adults who lack documentation of vaccination should receive at least 1 dose of MMR vaccine unless they have laboratory evidence of immunity. Two doses of vaccine, separated by at least 28 days, are recommended for adults previously vaccinated with the killed (or an unknown) measles vaccine used in the 1960s and for those at high risk for exposure and transmission of measles or mumps, including students in postsecondary educational institutions, healthcare workers, international travelers, and adults living in communities experiencing a major outbreak.27 MMR vaccination should be considered for healthcare workers born before 1957 if they do not have serologic or other acceptable evidence of immunity to measles, mumps, and rubella. The CDC recommends considering a third dose of MMR vaccine for control of a mumps outbreak in a highly vaccinated population in a setting with intense exposure, high attack rates, and evidence of ongoing transmission.28

One dose of MMR vaccine should be administered to nonpregnant women of childbearing age who lack serologic evidence of immunity to rubella. **Pregnant women** who do not have evidence of immunity to rubella should receive MMR vaccine postpartum, ideally before discharge from the healthcare facility.

**Adverse Effects** – Pain and erythema at the injection site (fever, rash, and transient arthralgias (about 25% of women) are common following MMR vaccination. Systemic anaphylactic reactions and thrombocytopenic purpura occur rarely.27 There is no evidence to support a causal link between MMR vaccination and autism.29
**Contraindications** – Because MMR is a live vaccine, it is contraindicated in pregnant women (the risk of congenital rubella syndrome may be only theoretical; it has not been reported among the thousands of infants born to women vaccinated inadvertently during pregnancy) and in patients with severe immunodeficiency. Patients with a history of anaphylaxis caused by neomycin should not receive the vaccine.

**PNEUMOCOCCAL** — A 23-valent inactivated pneumococcal polysaccharide vaccine (PPSV23; Pneumovax 23) has been available for many years for use in adults. The serotypes contained in the vaccine account for 88% of the strains that cause bacteremic pneumococcal disease. The vaccine is effective in preventing invasive disease, but randomized controlled trials and cohort studies have not consistently shown a decrease in non-invasive pneumococcal pneumonia among vaccinees.31,32

A conjugate vaccine that contains 13 serotypes of pneumococcus (PCV13; Prevnar 13) is also FDA-approved for use in adults.33 The pneumococcal serotypes in PCV13 cause about half of the cases of invasive pneumococcal disease in immunocompromised adults; an additional one-fifth are caused by serotypes contained only in PPSV23. Studies in immunocompetent adults ≥50 years old found that antibody responses to PCV13 were comparable to those with PPSV23, but patients who had previously received PPSV23 had lower antibody responses to PCV13 than those who had not received PPSV23 previously.34 No data on the immunogenicity of PCV13 in immunocompromised adults are available. An unpublished placebo-controlled trial in 85,000 adults ≥65 years old found that vaccination with PCV13 reduced first episodes of vaccine-type community-acquired pneumonia and invasive pneumococcal disease by 46% and 75%, respectively.35

**Recommendations for Use** – A one-time dose of PPSV23 is recommended for all adults ≥65 years old. The vaccine is also recommended for adults <65 years old who smoke, reside in long-term healthcare facilities, or who are at moderate or high risk for invasive pneumococcal disease because of diabetes, renal failure, heart disease, pulmonary disease (including asthma), liver disease or alcoholism, cochlear implants, cerebrospinal fluid leaks, immunocompromising conditions, or asplenia. A second dose of PPSV23 should be given after 5 years to adults <65 years old with immunocompromising conditions, chronic renal failure or nephrotic syndrome, or functional or anatomic asplenia. All persons who received PPSV23 before 65 years of age should be revaccinated at or after age 65, at least 5 years after the previous vaccination. PPSV23 induces attenuated antibody production after subsequent doses, which may be caused by depletion of the peripheral memory B cell population.36

PCV13 is recommended for adults ≥19 years old with immunocompromising conditions (including HIV infection, chronic renal failure, or nephrotic syndrome), functional or anatomic asplenia, cerebrospinal fluid leaks, or cochlear implants. If these patients have not been previously immunized with PPSV23, they should receive PCV13 first, followed 8 weeks later by PPSV23. Patients who have previously received PPSV23 should receive PCV13 at least one year after the last dose of PPSV23. Additional doses of PPSV23, if required, should be given no sooner than 8 weeks after PCV13.34

**Adverse Effects** – Mild to moderate soreness and erythema at the injection site are common with both vaccines.

**HEPATITIS A** — Hepatitis A virus (HAV) infection occurs frequently in the US and is endemic in certain communities in the western and southwestern states and in Alaska. In the US, the prevalence of anti-HAV antibodies ranges from about 9% in preadolescent children to about 75% in elderly adults.37 Hepatitis A vaccination has been part of routine pediatric immunization in the US since 1996. Two inactivated hepatitis A whole-virus vaccines (Vaqta, Havrix) are available in the US. Twinrix, the combination hepatitis A and B vaccine, contains the same hepatitis A component as in Havrix, but at half the dose.

**Recommendations for Use** – Hepatitis A vaccine is recommended for adults with a medical, occupational, or behavioral risk of infection. Medical indications include clotting factor disorders or chronic liver disease. Occupational indications include work with hepatitis A-infected primates. Adults with behavioral risks include illicit (injection and non-injection) drug users and men who have sex with men. Hepatitis A vaccine is also recommended for close contacts of adopted children from countries with intermediate or high rates of hepatitis A infection and for susceptible travelers going anywhere other than Canada, Australia, New Zealand, Japan, or western Europe.

Hepatitis A vaccination in adults usually consists of 2 doses separated by at least 6 months. After a single dose, Havrix provides protection for at least 12 months, and Vaqta for at least 18 months. Patients who receive Twinrix should receive 3 doses at 0, 1, and 6 months. Twinrix can also be given in an accelerated 4-dose schedule; the first 3 doses are given at 0, 7, and 21-30 days, and the fourth at 12 months. Patients who have received a first dose of one hepatitis A vaccine can be
Adult Immunization

given another one to complete the series. Booster doses are not recommended for immunocompetent adults who have completed a primary immunization series.

Adverse Effects – Local injection-site reactions such as pain, swelling, or erythema occur in 20-50% of vaccine recipients. Mild systemic complaints such as malaise, low-grade fever, or fatigue occur in less than 10% of vaccines.

HEPATITIS B — Routine vaccination of infants against hepatitis B has been standard in the US since 1991. Available formulations of the vaccine contain hepatitis B surface antigen (HBsAg) protein. The hepatitis B component in the combined hepatitis A and B vaccine (Twinrix) is the same as in Engerix-B.

Recommendations for Use – Hepatitis B immunization is recommended for adults with a medical, occupational, or behavioral risk of infection. Medical indications are end-stage renal disease (including hemodialysis), chronic liver disease, diabetes (particularly in persons 19-59 years old), or HIV infection. Occupational indications include healthcare or public safety work with potential exposure to blood or body fluids. Adults with behavioral risks include injection drug users, those who had sex with more than one partner in the previous 6 months or recently acquired a sexually transmitted infection, and men who have sex with men.

Other populations who should receive hepatitis B vaccination include residents of facilities for the aged and chronically ill, staff and clients of facilities that test for and treat sexually transmitted infections, HIV, or drug abuse, residents and staff members of institutions for the developmentally disabled, inmates and staff of correctional facilities, household contacts and sex partners of persons with chronic hepatitis B infection, and travelers to countries with intermediate or high rates of chronic hepatitis B infection.

Primary immunization with hepatitis B vaccine usually consists of 3 doses given at 0, 1, and 6 months. An alternate schedule of 3 doses given at 0, 1, and 2 months, followed by a fourth dose at 12 months, is approved for Engerix-B in the US and is only intended for use in certain populations, including those who have been recently exposed to the virus and travelers to high-risk areas. Twinrix can also be given in an accelerated 4-dose schedule with the first 3 doses at 0, 7, and 21-30 days, and the fourth at 12 months. An interrupted hepatitis B vaccination series does not have to be restarted. A 3-dose series started with one hepatitis B vaccine may be completed with another. Booster doses are not recommended for most adults who have completed a primary immunization series.

Adverse Effects – The most common adverse effect of hepatitis B vaccination is pain at the injection site. Fever occurs in <10% of recipients.

MENINGOCOCCAL — About 800-1200 cases of meningococcal disease occur in the US each year. The case fatality rate is 10-15% for meningitis and up to 40% for meningococcemia. Rates of meningococcal disease are highest in infancy. A second peak occurs in adolescents and young adults, especially first-year college students living in dormitories, and a third peak occurs in adults ≥65 years old. Five major serogroups of Neisseria meningitidis – A, B, C, Y, and W-135 – cause most human infection.

Three quadrivalent inactivated vaccines are available against N. meningitidis serogroups A, C, Y, and W-135. Menomune contains meningococcal capsular polysaccharides. Menactra and Menveo both contain the same capsular polysaccharides, each conjugated to different diphtheria toxoid proteins. In adults, all three vaccines induce serotype-specific antibody responses in more than 90% of recipients. None of these vaccines provide protection against serogroup B.

Recommendations for Use – Vaccination is recommended for adolescents 11-18 years old, adults with functional or anatomic asplenia or persistent complement component deficiencies, first-year college students living in dormitories (if not vaccinated within the previous 5 years), laboratory personnel routinely exposed to isolates of N. meningitidis, military recruits, persons at risk during an outbreak caused by a vaccine serogroup, and persons who travel to or reside in countries in which meningococcal disease is hyperendemic or epidemic, particularly those in the “meningitis belt” of sub-Saharan Africa. The government of Saudi Arabia also requires vaccination (within 3 years before travel) for pilgrims during the annual Hajj.

Adults with functional or anatomic asplenia or persistent complement component deficiencies should receive two doses of the conjugate vaccine administered 8-12 weeks apart. Vaccination is not routinely recommended for HIV-infected persons, but if they are considered to be at increased risk for meningococcal disease, they should receive a 2-dose primary series. For all others, a single dose of vaccine is recommended. In general, the conjugate vaccine should be used for persons ≤55 years old and the polysaccharide for those ≥56 years old, but adults ≥56 years old who anticipate needing multiple doses should receive the conjugate vaccine. Serologic data show a significant decline in serum antibody titers 3-5 years after vaccination with the conjugate vaccine.
Adverse Effects – The most common adverse reactions to Menactra and Menveo are headache, fatigue, malaise, and injection-site pain, redness, and induration. The rates of these reactions are higher than with Menomune, but similar to those with tetanus toxoid. Guillain-Barré syndrome has been reported rarely in adolescents who received Menactra, but the risk appears to be very low (0-1.5 cases/1 million vaccines within 6 weeks following vaccination).41

Serogroup B Vaccine – Until recently, no serogroup B vaccine was widely available because the polysaccharide capsule of the B serogroup, unlike those of the other main meningococcal serogroups (A, C, Y, and W-135), is only weakly immunogenic. Outbreaks of meningococcal disease at Princeton University and the University of California at Santa Barbara caused by N. meningitidis serogroup B led the FDA and CDC to permit importation and investigational use of a meningococcal B vaccine (4CMenB; Bexsero – Novartis). Bexsero has been approved for use in the European Union and in Australia. Its efficacy has not been established clinically. Bactericidal antibody levels develop about 2 weeks after one dose of the vaccine. The recommended vaccination schedule for adults is 2 doses administered one month apart. No booster dose is recommended.43,44

HAEMOPHILUS INFLUENZAE TYPE B — Haemophilus influenzae type b (Hib) can cause bacterial meningitis and other invasive diseases. The majority of Hib disease in the US occurs in infants and children; routine vaccination of young children is recommended by the ACIP. Since the introduction of conjugate Hib vaccines in 1987 and 1989, the incidence of invasive disease caused by H. influenzae type b in children <5 years old in the US has decreased dramatically. The average annual incidence rate during 2000-2012 was <0.27/100,000.45 Two monovalent Hib conjugate vaccines (PedvaxHIB and ActHIB) are available in the US.

Recommendations for Use – Hib vaccination is only recommended for immunocompromised adults who are considered at increased risk for invasive Hib disease. A single dose of any Hib conjugate vaccine should be administered to unimmunized adults (no primary series and booster or single dose after the age of 14 months) who are asplenic or who are scheduled for an elective splenectomy (≥14 days before the procedure). Some experts suggest administering one dose to these patients regardless of prior vaccination history. Three doses of Hib vaccine (given at least 4 weeks apart) are recommended for recipients of a hematopoietic stem cell transplant, including those who had previously been vaccinated, beginning 6-12 months after the transplant. Hib vaccination is not recommended for HIV-infected adults.

Adverse Effects – Hib vaccine has not been studied in adults. In children, erythema, pain, and swelling at the injection site, mild fever, irritability, vomiting, and diarrhea have occurred.

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The expected outcome of the CME program is to increase the participant's ability to know, or apply knowledge into practice after assimilating, information presented in materials contained in Treatment Guidelines.

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Upon completion of this program, the participant will be able to:

1. Discuss the current recommendations for routine vaccination of adults in the US.
2. Review available vaccine preparations and their recommended dosages, possible adverse effects, and contraindications for use.

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1. Live-attenuated vaccines:
   a. contain a weakened form of the pathogen
   b. are contraindicated during pregnancy
   c. cause more adverse effects than inactivated vaccines
   d. all of the above

2. Compared to trivalent influenza vaccines, the quadrivalent vaccines contain an additional strain of:
   a. influenza A virus
   b. influenza B virus
   c. influenza C virus
   d. avian influenza

3. Which of the following persons should receive Tdap?
   a. a 42-year-old woman presenting to the ER after stepping on a nail who has not previously received Tdap
   b. a 26-year-old woman pregnant with her second child who received a dose of Tdap during her first pregnancy 3 years ago
   c. a 30-year-old man whose wife is pregnant and who did not receive a Tdap dose during adolescence
   d. all of the above

4. Pregnant women should be vaccinated with Tdap during which trimester of pregnancy?
   a. first
   b. second
   c. third
   d. Tdap is contraindicated during pregnancy

5. Which of the following HPV types are found in Cervarix?
   a. 6 and 11
   b. 6 and 16
   c. 16 and 18
   d. 6, 11, 16 and 18

6. A 22-year-old woman with an abnormal Pap smear secondary to HPV and no history of HPV vaccination asks you if she should receive the HPV vaccine. You could tell her that:
   a. since she has already been infected with HPV, it is too late to receive the vaccine
   b. she is too old to be vaccinated
   c. she should receive the quadrivalent vaccine because it has been shown to offer longer protection
   d. none of the above

7. Which of the following is true of the zoster vaccine?
   a. It is FDA-approved for use in persons ≥50 years old.
   b. It is recommended for all immunocompetent adults ≥50 years old.
   c. It is safe for use during pregnancy.
   d. It is safe for use in patients with a history of anaphylaxis to neomycin.

8. Which of the following is contraindicated for use during pregnancy?
   a. Flumist
   b. Zostavax
   c. Varivax
   d. all of the above

9. Two doses of MMR vaccine are recommended for all of the following groups except:
   a. healthcare workers born after 1957
   b. adults born before 1957
   c. adults who received the killed measles vaccine used in the 1960s
   d. travelers to countries where measles is endemic

10. For control of a mumps outbreak in a highly vaccinated population, the CDC recommends considering use of:
    a. IVIG
    b. a 3rd dose of MMR vaccine
    c. antiviral drugs
    d. all of the above

11. Which of the following statements about pneumococcal vaccination is true?
    a. PPV23 is recommended for all adults ≥65 years old.
    b. Previously unimmunized persons should be given PPV23 before PCV13.
    c. PCV13 is recommended for all adults ≥19 years old.
    d. all of the above

12. A 34-year-old healthy woman with an uncertain history of primary vaccinations and childhood illnesses has just given birth. She did not receive any vaccines during her pregnancy. Which of the following vaccines would be appropriate to administer before hospital discharge?
    a. Tdap
    b. varicella
    c. MMR
    d. all of the above