Immunizations in Adults

This is a PDF version of the following document:
Section 2: Basic HIV Primary Care
Topic 4: Immunizations in Adults

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Background

Background

Providing appropriate immunizations is an important component of comprehensive HIV clinical care. Immunizing persons with HIV poses several challenges and concerns related to safety and efficacy. The immunizations topics discussed in this review are ordered alphabetically based on the vaccine.

Recommendations by Organizations

The Advisory Committee on Immunization Practices (ACIP) provides annual recommendations for routine immunizations of adults, including HIV-specific recommendations.[1] In 2013, the Infectious Disease Society of America (IDSA) issued IDSA Vaccine Guidelines for the Immunocompromised Host, but these guidelines have not been updated.[2] Unfortunately, some differences exist in the recommendations provided by the different organizations, which creates a challenge for clinicians. This topic review will focus on common adult immunizations (Table 1),[3] with a discussion of specific recommendations for adults living with HIV (Table 2).[1]

Safety Concerns

Early in the HIV epidemic, several reports generated concern that vaccinations in persons with HIV could activate their cellular immune system and enhance HIV replication, thereby increasing HIV RNA levels and potentially accelerating the course of HIV disease.[4] These reports, however, involved persons with HIV who were not receiving potent antiretroviral therapy and investigators subsequently demonstrated that post-immunization increases in HIV RNA levels were transient and clinically insignificant. Further, in persons taking modern highly potent antiretroviral therapy, immunizations generally do not cause any detectable increases in plasma HIV RNA levels. Current guidelines recommend that immunizations should not be withheld in persons with HIV due to concerns of increases in HIV RNA levels.[2,5]

Risk of Live Vaccines in Persons with HIV Infection

Immunizations are generally safe in individuals with HIV, with the exception of live virus vaccines in patients with low CD4 counts. In persons with HIV who have advanced immunosuppression, live vaccines can cause a potentially life-threatening disseminated infection with the live pathogen in the vaccine.[6]

Challenges with Efficacy
Unfortunately, current or past advanced immunosuppression in persons with HIV is often associated with suboptimal responses to standard recommended vaccine doses; response to several vaccines appears to depend on current and nadir CD4 cell counts.[7, 8, 9, 10] In general, responses to immunization are better when the vaccine is given as early as possible in the course of HIV infection or after immune reconstitution that has resulted from antiretroviral therapy.
Haemophilus influenzae type b (Hib) Vaccine

Background

*Haemophilus influenzae* infection is more common in adults with HIV than in the general population, but the annual incidence remains relatively low at 41/100,000 adults with HIV.[11] Only about one-third of cases of invasive *H. influenzae* involve type b, which is the type in the currently licensed vaccines. Multiple identifiable subtypes of *H. influenzae* and other unidentifiable types (called nontypeable *H. influenzae*) can cause a wide range of clinical disease, including bacteremia, meningitis, pneumonia, epiglottitis, cellulitis, and infectious arthritis. Infants and children younger than five years of age, adults over the age of 65, and Native American and Alaskan Indian populations are all at higher risk of disease.[12] Certain medical conditions also predispose individuals to *H. influenzae* disease, such as HIV, sickle cell disease, asplenia, complement and antibody deficiency syndromes, and receipt of chemotherapy, radiation or hematopoietic stem cell transplant. The conjugate *H. influenzae* type b vaccine is safe and effective in all age groups.[13]

Vaccines

The currently licensed *Haemophilus influenzae* type b conjugate vaccines are *Hiberix*, *ActHIB*, and *PedvaxHIB*. Additional Hib conjugate vaccines are licensed in combination with other vaccines, including *Comvax* (Hib combined with hepatitis B vaccine), *Pentacel* (Hib combined with DTaP and inactivated polio virus), and *MenHibrix* (Hib combined with meningococcal vaccine).

Recommendations

- Due to the low incidence of *H. influenzae* type b infections among adults with HIV, *H. influenzae* type b immunization is not recommended for routine administration to adults with HIV.[14]
- Per the 2020 ACIP Adult Immunization Schedule, one dose of Hib vaccine should be administered to adults with HIV only if they have an indication for the vaccine, namely sickle cell disease, leukemia, or anatomic or functional asplenia.[1]
Hepatitis A Virus (HAV) Vaccine

Background

Hepatitis A virus (HAV) is transmitted through food, water, or objects contaminated with fecal matter. Rates of HAV infection in the United States have markedly declined in the past 20 years, likely due to the widespread use of the hepatitis A vaccine since 1995. During the last several years, however, rates have increased dramatically as a result of multiple outbreaks that have primarily involved homeless persons, men who have sex with men, persons who inject drugs, and to a lesser degree, with consumption of imported contaminated food. For persons with HIV, the hepatitis A vaccines are safe and moderately effective, though seroconversion rates may be diminished for individuals with lower CD4 cell counts. One randomized control study found seroconversion rates of 94% in persons with HIV compared to 100% in persons without HIV infection, though rates were only 87% in patients with CD4 counts less than 300 cells/mm$^3$. In another randomized control trial, after two doses of hepatitis A vaccine, seroconversion rates were observed in 68% of persons with HIV who had a CD4 count greater than or equal to 200 cells/mm$^3$ compared to only 9% of those with CD4 counts less than 200 cells/mm$^3$.

Vaccines

Hepatitis A vaccine is an inactivated vaccine that can be given either as Havrix or Vaqta, or as part of a combination vaccine (Twinrix) that contains both inactivated hepatitis A and recombinant hepatitis B vaccine. Havrix contains 1,440 ELISA units (El.U) of hepatitis A antigen and Vaqta contains 50 units (U) of inactivated hepatitis A; Twinrix contains 720 El.U of hepatitis A antigen (half of the Havrix dose) combined with 20 mcg of hepatitis B antigen (the full Engerix-B dose). The two brands of hepatitis A are interchangeable.

Recommendations

The following summarizes the 2020 ACIP Adult Immunization Schedule for administering hepatitis A vaccine to persons with HIV. The current recommendations for persons with HIV represent a departure from prior recommendations, mainly due to the increases in hepatitis A infections in the United States in recent years.

- **General Approach**: Administer Hepatitis A vaccination to all persons with HIV, regardless of CD4 count.
- **Timing of Vaccine**: Persons with HIV should ideally be vaccinated against hepatitis A prior to a decline in CD4 counts, but vaccination should not be delayed in individuals with HIV, including those with a CD4 count less than 200 cells/mm$^3$.
- **Recommended Dosing Schedule**: The ACIP Adult Immunization Schedule recommends administering hepatitis A vaccine in two doses at 0 and 6 to 12 months (Havrix) or 0 and 6 to 18 months (Vaqta); the minimum interval before the first and second dose of these vaccines is 6 months. The combined hepatitis A-hepatitis B vaccine (Twinrix) can also be administered as a 3-dose series (0, 1, and 6 months); the minimum intervals are 4 weeks between the first and second doses and 5 months between the second and third doses.
Hepatitis B Virus (HBV) Vaccine

Background

Hepatitis B virus (HBV) is transmitted through percutaneous and mucosal exposure to infected blood or body fluids. Chronic infection with HBV can cause cirrhosis, liver failure, hepatocellular cancer, and death. Individuals with HIV have an increased risk of acquiring HBV through injection drug use and/or condomless sex. When compared to persons with HBV monoinfection, those coinfected with HIV and HBV have an increased likelihood of establishing chronic HBV after initial infection, accelerated progression of liver disease, and significantly higher rates of liver-related mortality compared with individuals not infected with HIV.\cite{18,19}

In light of these risks, vaccination against HBV is very important for persons with HIV infection. Unfortunately, hepatitis B vaccine response rates in adults with HIV are significantly lower than in adults without HIV, with response rates in persons with HIV, ranging from 18 to 71\% in persons with HIV compared to 60 to 80\% in those without HIV.\cite{20,21} Lower HBV vaccine response in persons with HIV have been associated with a recent or nadir CD4 count less than 200 cells/mm$^3$, detectable HIV RNA levels, and coinfection with hepatitis C virus.\cite{10,20} Attempts to improve hepatitis B vaccine response rates have included giving a double dose (40 mcg of the hepatitis B surface antigen [HBsAg] instead of 20 mcg), increased number of doses (four instead of three), and using intradermal rather than intramuscular dosing.\cite{22,23,24}

Vaccines

For adults, there are three FDA-approved HBsAg recombinant vaccines hepatitis that are widely used: Recombivax-HB, Engerix-B, and Heplisav-B. The Engerix-B vaccine is available in doses that contain 20 mcg of HBsAg. The Recombivax-HB is available as a standard 10 mcg HBsAg per dose and a high-dose dialysis formulation (40 mcg per dose). A combined hepatitis A-hepatitis B (Twinrix) vaccine is also available, which contains 20 mcg per dose of HBsAg and 720 El.U of hepatitis A. The Heplisav-B, which includes the CpG adjuvant, is available in doses that each contain 20 mcg of HBsAg and 3,000 μg of the 1018 adjuvant;\cite{25} four randomized trials performed in immunocompetent persons have shown that two doses of Heplisav-B vaccine generated a higher rate of seroprotection than three doses of the Engerix-B vaccine.\cite{26,27,28,29}

Recommendations

The recommendations for hepatitis B immunization in persons with HIV are outlined as follows.\cite{1,19,19}

- **General Approach**: The 2020 ACIP Adult Immunization Schedule and the Adult and Adolescent Opportunistic Infection Guidelines recommend all persons with HIV who do not have active HBV or evidence of immunity to HBV should receive the hepatitis B vaccine series, regardless of CD4 cell count.\cite{1,19,19}

- **Prevaccine Screening**: Prevaccine screening should include HBsAg, anti-HBs, and anti-HBc. A positive HBsAg indicates active infection and no vaccine is indicated. If the patient has a positive anti-HBs and anti-HBc, the patient does not need immunization. In addition, if the anti-HBs alone is positive (with a titer greater than 10 mIU/mL), the patient is considered immune and has no need for hepatitis B immunization.\cite{19,25} The approach to patients with isolated anti-HBc is addressed below.

- **Timing of Vaccine**: The Adult and Adolescent Opportunistic Infection Guidelines recommend providing hepatitis B vaccine to nonimmune individuals at entry into care and ideally before CD4 count declines to less than 350 cells/mm$^3$, since vaccine responses are better at higher CD4 cell counts.\cite{19} Nevertheless, the guidelines recommend that patients who initially present with a low CD4 count should receive hepatitis B vaccine without delay, as some patients with a low CD4 will respond to the vaccine.\cite{19}

- **Dosing and Schedule**: The ACIP Adult Immunization Schedule does not provide unique dosing recommendations for persons with HIV.\cite{1} The Adult and Adolescent Opportunistic Infection Guidelines recommend the following for hepatitis B vaccine in persons with HIV (Figure 2):\cite{19}
Standard 3-dose series of hepatitis B vaccine (*Engerix-B* or *Recombivax-HB*) given at 0, 1, and 6 months (*AII*), or
- Double doses of hepatitis B vaccine (*Engerix-B* or *Recombivax-HB*) given as a 4-dose series at 0, 1, 2, and 6 months (*BI*), or
- Combined hepatitis A and B vaccine (*Twinrix*) given as a 3-dose series (0, 1, and 6 months) or a 4-dose series (0, 7, and 21 to 30 days, and 6 months) (*AII*), or
- Vaccine conjugated to CpG (*Heplisav-B*) given as a 2-dose series at 0 and 1 months; this 2-dose series is only recommended if both doses given are *Heplisav-B* (*CIII*). Note that *Heplisav-B* should not be used in pregnant individuals due to lack of safety data.

**Postvaccine Antibody Testing:** Given the decreased response rate to hepatitis B vaccine among persons with HIV, postvaccine testing for antibody to hepatitis B surface antigen (anti-HBs) should be performed 1 to 2 months after completing the final dose of the vaccine series, with a titer of at least 10 mIU/mL considered protective; individuals who have a postvaccine anti-HB less than 10 mIU/mL are considered vaccine nonresponders.[2,19]

**Repeat Immunization for Vaccine Nonresponders:** If a post-vaccination anti-HBs concentration of at least 10 mIU/mL is not attained, the Adult and Adolescent Opportunistic Infection Guidelines recommend the following as options for these vaccine nonresponders:[19]
- Administer a 4-dose series of double-dose hepatitis B vaccine (*Engerix-B* or *Recombivax-HB*) given at 0, 1, 2, and 6 months (*BI*).
- Give a second hepatitis B vaccine series (using a standard dose) (*BIII*).
- If the CD4 cell count was less than 200 cells/mm\(^3\) at the time of the initial vaccine series, some experts would recommend delaying the second vaccine series until the patient has a sustained increase in CD4 count in response to antiretroviral therapy (*CIII*).

**Isolated Core Antibody:** The optimal approach for patients with HIV infection with isolated anti-HBc (positive anti-HBc, negative anti-HBs, and negative HBsAg) is unclear since this pattern may signify a false positive result, exposure in the distant past with waning anti-HBs, or occult HBV infection. The Adult and Adolescent Opportunistic Infection Guidelines recommend administering one standard dose of hepatitis B vaccine and then checking an anti-HBs titer 1 month later (*Figure 3*).[19] If the anti-HBs titer is greater than 100 mIU/mL then no additional hepatitis B vaccines need to be administered and the person is considered immune to HBV. If the anti-HBs titer is less than 100 mIU/mL, then a full hepatitis B vaccine series should be administered and postvaccine anti-HBs titer checked. Note with this approach to persons with isolated core antibody, the cut-off representing immunity after the one vaccine dose (100 mIU/mL) is 10-fold higher than the 10 mIU/mL used to represent immunity following receipt of the HBV immunization series in persons who do not have isolated hepatitis B core antibody.
Human Papillomavirus (HPV) Vaccine

Background

Individuals with HIV have a high burden of human papillomavirus (HPV)-associated disease compared to persons who do not have HIV: genital warts are more common in women and men, abnormal cervical cytology is nearly 11 times more common in women, and anal cancer is approximately 30-fold higher among men.[30,31,32] For persons with HIV, the impact of the widespread use of antiretroviral therapy on the incidence of cervical cancer in women and anal cancer in men is uncertain.[33,34,35] Early studies reported unchanged or increasing incidence of these cancers, suggesting a reversal of HIV-induced immunosuppression does not overcome the long latency of the carcinogenic effects of HPV.[32,36] More recent reports in persons with HIV have found a marked decline in cervical and anal cancer risk in women and men.[37] In addition, population level analyses of large HPV vaccination programs have demonstrated a reduced prevalence of HPV subtypes responsible for cervical cancer and genital warts in adolescent girls and boys, thereby signaling significant future benefit, both directly from immunization and indirectly through herd immunity.[33] Further, a recent study that examined the prevalence of vaccine-type oral HPV in a large sample of unvaccinated men, aged 18 to 59 years, noted a 37% decline between 2009-2010 and 2015-2016.[38]

Vaccines

In the United States, the 9-valent (9vHPV) vaccine is the only HPV vaccine currently manufactured. The 9vHPV vaccine includes 7 cancer-causing HPV serotypes (16, 18, 31, 33, 45, 52, and 58).[39] The HPV serotypes 16 and 18 account for approximately 66% of cases of cervical cancer; the HPV serotype 31, 33, 45, 52, and 58 combined account for approximately 15% of cervical cancers and 10% of invasive HPV-associated cancers.[39] The 9vHPV vaccine also contains HPV serotypes 6 and 11, which account for approximately 90% of genital warts.[39] The HPV vaccines are prepared from recombinant noninfectious virus-like particles and are considered safe for immunocompromised individuals since they do not pose any risk of transmitting infection (Figure 1). The 9vHPV vaccine is FDA-approved for use in females and males 9 through 45 years of age.[40] Use of HPV vaccination in persons with HIV is safe and effective, with seroconversion rates of 95% in men 18 years of age and older who received the quadrivalent vaccine, and seroconversion rates of 92.3 to 100% among women with HIV aged 16 to 23 years who received the quadrivalent vaccine.[34,35] Being on suppressive antiretroviral therapy may improve vaccine response.[34]

Recommendations

- **General Approach:** The 2020 ACIP Adult Immunization Schedule and the Adult and Adolescent Opportunistic Infection Guidelines recommend administering the 9vHPV vaccine series routinely for persons with HIV who are 9 through 26 years of age.[1,41] The 9vHPV vaccine is not recommended for persons with HIV who are older than 26 years of age. The indication for administering the 9vHPV vaccine to persons with HIV is based only on the individual’s age and not on past sexual history, HPV or Pap smear testing, or history of genital warts.

- **Dosing Recommendation:** For persons with HIV, the HPV vaccination should be given in a 3-dose series (given at 0, 1-2, and 6 months).[1,39,41] A 2-dose schedule is now recommended for healthy boys and girls 9 through 14 years of age, but this 2-dose series should not be used in persons with HIV.[1,42]

- **HPV Vaccine in Pregnancy:** The ACIP Adult Immunization Schedule recommends against administering HPV vaccine to pregnant women, but pregnancy testing is not needed prior to vaccination.[1,39] If a woman is found to be pregnant after vaccination, no intervention is needed. In addition, if a woman has started the vaccine series and becomes pregnant, the remainder of the 3-dose series should be delayed until completion of pregnancy. The largest HPV vaccine pregnancy registry to date shows no adverse signals and at this time, pregnancy registries for the bivalent and quadrivalent vaccines have been closed.[39,43] In addition, recent data with 4vHPV suggest that HPV
vaccine is safe when given during pregnancy.

- **Use as Therapeutic Vaccine**: The HPV vaccine is not recommended for therapeutic purposes for persons with HPV-related abnormal cervical or anal cytology.
Influenza Vaccine

Background

Influenza viruses typically circulate widely in the United States annually from the late autumn through early spring. Influenza A and influenza B are the types of viruses that cause human epidemic disease. New variants emerge due to frequent antigenic change (i.e. antigenic drift) resulting from point mutations and recombination events that occur during viral replication; antigenic drift is the virologic basis for seasonal epidemics and necessitates adjustment of the vaccine components each year.[44] Larger antigenic change, termed antigenic shift, has the potential to cause a worldwide pandemic since there is no preexisting immunity among humans to the novel virus in this situation. Annual influenza vaccination is the primary means of preventing influenza and its complications. Persons with HIV have a higher risk of influenza-associated morbidity and mortality compared to persons without HIV.[45] Studies in individuals with HIV suggest a single dose of inactivated vaccine generates a good humoral immune response, except in those with a low CD4 cell count.[8]

Vaccines

All adults with HIV, including pregnant women, can receive inactivated influenza vaccine (IIV). The inactivated influenza vaccine options now include trivalent (contains two strains of influenza A and one of influenza B) and quadrivalent vaccines (contains two strains of both influenza A and B). Most of the influenza vaccines available for the 2019-2020 influenza season are quadrivalent vaccines. A recombinant quadrivalent influenza vaccine (RIV) that does not contain any egg protein is approved for adults. The quadrivalent live attenuated influenza vaccine (LAIV), also known as the nasal spray flu vaccine, is approved for use in adults 18 through 49 years of age, but it has not been adequately studied for use in immunocompromised individuals, including persons with HIV. As such, experts do not recommend giving living attenuated influenza vaccine to persons with HIV due to concern that attenuated virus could lead to influenza virus infection.

Recommendations

The following summarizes the 2020 ACIP Adult Immunization Schedule and the Adult and Adolescent Opportunistic Infection Guidelines for administering influenza vaccine to persons with HIV infection.[1,14]

- **General Approach:** All persons with HIV should receive a single annual dose influenza vaccine.
- **Recommended Vaccines:** Recommended routine influenza vaccines for persons with HIV include inactivated influenza vaccine (IIV) or recombinant influenza vaccine (RIV).
- **Contraindicated Vaccine:** The live attenuated influenza vaccine (LAIV) is contraindicated in persons with HIV.
- **Persons 65 and Older:** Adults with HIV who are 65 years of age and older can receive the quadrivalent high-dose inactivated influenza vaccine.
- **Persons with Egg Allergy:** The recombinant influenza vaccine (RIV), which does not use an egg-based culture system, is available and safe for persons with an egg allergy.
Measles-Mumps-Rubella (MMR) Vaccine

Background

Measles, mumps, and rubella are highly contagious viruses that can cause a wide range of clinical disease, including congenital syndromes. Since the introduction of the measles-mumps-rubella (MMR) vaccine, the incidence of these viral diseases has decreased by 99%.[46] Nevertheless, despite good MMR vaccine coverage in the United States, outbreaks continue to occur. Between January 1 and December 31 2019, more than 1,200 cases of measles were diagnosed in the United States, which is the largest number of annual cases reported in the United States since 1992 (Figure 4).[47]

Impact of Measles in Persons with HIV

Measles can cause significant morbidity and mortality in healthy individuals, and the impact is even greater in immunosuppressed persons, with one case report citing 40% mortality in patients with HIV.[46] Studies suggest that most individuals with HIV in the United States have adequate antibody titers to measles, although data from an ongoing observational cohort of United States Department of Defense beneficiaries found a seroprevalence of measles immunity of only 67%.[48] Adults born before 1957 are considered immune to measles.[49] Based on limited available data, the immunologic responses to the MMR vaccine among individuals with HIV is modest at best, and the protection of the vaccine in persons with HIV is not well established; MMR does not appear to have any significant detrimental impact on either CD4 count or HIV RNA levels.[48]

Measles Vaccines

In the United States, in 1963 both live attenuated measles vaccine and the inactivated measles vaccine became available for use.[49] In 1967, the inactivated vaccine was discontinued after it was shown to be ineffective.[49] In 1971, the MMR vaccine became available and is still widely used. There is also a quadrivalent measles-mumps-rubella-varicella (MMRV) vaccine that is approved by the FDA, but it is rarely used in adults. All measles vaccines that are currently used contain live attenuated measles virus and thus pose significant risk to severely immunocompromised individuals, including persons with HIV who have low CD4 cell counts. There have been case reports of fatal pneumonitis in persons with HIV and advanced immunosuppression who received the MMR vaccine.[50]

Recommendations

The following summarizes the 2020 ACIP Adult Immunization Schedule recommendation for administering MMR to persons with HIV.[1]

- **General Approach**: For persons with HIV and a CD4 count of 200 cells/mm$^3$ or greater (for at least 6 months) born in 1957 or later who do not have immunity to measles, give the two-dose MMR vaccine series, with the doses administered at least 4 weeks apart.
- **Quadrivalent Measles-Mumps-Rubella-Varicella (MMRV) Vaccine**: The quadrivalent MMRV vaccine is not recommended in persons with HIV, regardless of CD4 cell count.[2]
- **Persons with a CD4 Count Less than 200 cells/mm$^3$**: The MMR and MMRV vaccines are contraindicated in persons with HIV infection who have a CD4 count less than 200 cells/mm$^3$.
- **MMR in Pregnancy**: The MMR vaccine is contraindicated during pregnancy, and pregnancy should be avoided for 28 days after vaccination to minimize the theoretical risk of congenital rubella syndrome. Women without evidence of rubella immunity and a CD4 count of at least 200 cells/mm$^3$ should receive MMR vaccination upon completion or termination of pregnancy and before discharge from the health facility.
- **Persons who Received Measles Vaccine During 1963 through 1967**: Receipt of the inactivated (ineffectual) measles vaccine, which was an option during 1963 through 1967, does not count as a
dose of measles vaccine.[49] In addition, if the type of measles vaccine received during 1963-1967, is not known, then it does not count as a dose.[49]
Meningococcal Vaccine

Background

Meningococcal meningitis, which is caused by *Neisseria meningitidis*, can cause severe complications, including brain damage, hearing loss, and learning disabilities. Risk factors that can increase a person’s risk of acquiring meningitis include very young age (infants are at highest risk), community setting (college dormitory, military barracks), travel to endemic regions, and certain medical conditions, including HIV. Available data from population studies suggest that persons with HIV have an increased risk of developing meningococcal disease, with the relative risk estimated at 5- to 13-fold higher than in persons without HIV; the risk in persons with HIV infection appears to be higher with low CD4 cell counts and high HIV RNA levels. In addition, several local outbreaks of meningococcal meningitis have been reported in the United States involving gay and bisexual men. Unpublished CDC data from 62 cases of meningococcal disease in persons with HIV found that serogroup C was the most common isolate, followed next by serogroup Y. As with other vaccines given to individuals with HIV, low CD4 count and HIV RNA above 10,000 copies/mL are associated with decreased meningococcal vaccine response rate.

Vaccines

Two quadrivalent meningococcal conjugate vaccines (MenACWY) covering groups A, C, W-135, and Y are licensed and available for use in the United States: MenACWY-D and MenACWY-CRM. MenACWY is preferred for use in adults 55 years of age and younger as well as for adults aged 56 years and older who were either previously vaccinated with MenACWY and are recommended for revaccination, or in whom multiple doses are anticipated. In addition, serogroup B meningococcal vaccines (MenB) are now available, including MenB-4C, given as a 2-dose series and MenB-FHbp given as a 3-dose series. Both of the MenB vaccines are approved for persons aged 10 years and older who have increased risk for meningococcal disease.

Recommendations

The following summarizes the recommendations in the 2020 ACIP Adult Immunization Schedule regarding administering conjugate meningococcal vaccines to persons with HIV.

Meningococcal Conjugate Vaccine (A, C, W, Y)

- **General Approach**: Routine administration of meningococcal conjugate vaccine (serogroups A, C, W, Y) is recommended for persons with HIV; if possible, the same product of the meningococcal vaccine should be used for all doses.

- **Dosing Recommendations**: For adolescents and adults with HIV, give 2 doses (8 to 12 weeks apart) of either MenACWY-D or MenACWY-CRM. Follow-up booster doses should be given every 5 years beginning 5 years after the initial series.

Meningococcal B Vaccine

- **General Approach**: Administration of conjugate meningococcal B vaccine is recommended for persons with HIV only if they are 18 years or older, and they have an indication for receiving meningococcal B vaccine, such as functional or anatomic asplenia, persistent complement component deficiency or receipt of a complement inhibitor (e.g., eculizumab, ravulizumab). Of note, MenB vaccine should be avoided during pregnancy unless the individual is at increased risk of meningococcal infection.

- **Dosing Recommendations**: If MenB-4C is used, 2 doses should be given at least 1 month apart. If MenB-FHbp is used, then give 3 doses at 0, 1-2, and 6 months. If the second dose of MenB-FHbp was administered 6 months after the first dose in the series, then a third dose is not required. The
MenB-4C and the MenB-FHbp should not be used interchangeably. Persons should receive one booster dose of the MenB vaccine 1 year after completing the initial vaccine series, followed by boosters doses every 2-3 years if there is persistent risk of meningococcal infection.
Pneumococcal Vaccine

Background

In the general population, *Streptococcus pneumoniae* causes significant disease, including bacteremia, meningitis, and pneumonia, and is responsible for approximately 4,000 deaths each year in the United States. In the early years of the HIV epidemic, the risk of invasive pneumococcal disease in persons with HIV was approximately 20 times higher than in adults without high-risk conditions.[56] Subsequently, the incidence of invasive pneumococcal disease has decreased in persons with HIV, likely due to (1) the widespread use of potent antiretroviral therapy that resulted in improved immune function and improved humoral responses to pneumococcal antigens during clinical infections, and (2) population herd protection against invasive strains of *S. pneumoniae* following the widespread use of conjugate pneumococcal vaccines in children since 2000.[57,58,59,60,61] A study that examined the risk of invasive pneumococcal disease in persons with HIV during 1996 through 2011 at a large integrated healthcare system in the United States reported a sevenfold increased risk of invasive pneumococcal disease in adults with HIV compared with adults without HIV.[62]

Efficacy of Pneumococcal Immunization in Persons with HIV Infection

There are limited data that have addressed the efficacy of pneumococcal vaccination in persons with HIV. Retrospective studies indicate the 23-valent pneumococcal polysaccharide vaccine (PPSV23) alone has modest clinical benefit, if any, in reducing rates of pneumococcal infections in persons with HIV. In addition, the immunologic response to PPSV23 is impaired in persons with CD4 counts below 200 cells/mm$^3$.[60,63] Based on the lack of convincing data with PPSV23, significant interest emerged in using the conjugate pneumococcal vaccine, in combination with PPSV23. Further interest was generated after investigators demonstrated enhanced antibody responses to PPSV23 after initial immunization with the 7-valent conjugate pneumococcal vaccine (PCV7).[64] There are no published trials using the 13-valent pneumococcal conjugate vaccine (PCV13) in adults with HIV, but a randomized controlled trial in Malawi that used two doses of PCV7 given 1 month apart in 496 adults (88% with HIV) demonstrated a vaccine efficacy of 74% in preventing invasive pneumococcal disease; this study included a large number of patients with a CD4 count less than 200 cells/mm$^3$.[65] No data exist regarding the efficacy of the combined PCV13 plus PPSV23 vaccine regimen—the combination recommended for persons with HIV infection.

Vaccines

Two different pneumococcal vaccines are now available for use in the United States: PCV13 and PPSV23.[56] The PCV13 contains antigens from 13 common *S. pneumoniae* serotypes.[66] The PCV13 was approved by the United States Food and Drug Administration (FDA) in 2011 and it replaced the previously used PCV7. Of note, the PCV13 serotypes include all 7 serotypes in PCV7 (Figure 6).[66]

Recommendations

The 2020 ACIP Adult Immunization Schedule for pneumococcal immunization in adults with HIV combines the use of PCV13 and PPSV23, with the exact schedule based on age and whether the individual has previously received pneumococcal vaccine (Figure 7).[1,56]

- **General Approach**: In general, pneumococcal immunization should be given to all adults with HIV, ideally prior to CD4 decline and preferably after receipt of suppressive antiretroviral therapy. For individuals who have already experienced advanced immunosuppression and have a CD4 count less than 200 cells/mm$^3$, the PCV13 should be given without delay. In contrast, the timing of when to initiate PPSV23 in patients with advanced immunosuppression (CD4 count less than 200 cells/mm$^3$) remains unclear. Many experts would defer PPSV23 component until the individual achieves an increase in the CD4 count to greater than 200 cells/mm$^3$ as a result of suppressive antiretroviral therapy.[1,14,67]
- **No Prior Pneumococcal Immunization**: Adults with HIV who have never received pneumococcal vaccine should first receive one dose of PCV13, regardless of CD4 count, followed by a dose of PPSV23 (at least 8 weeks later). Note that if the CD4 count is less than 200 cells/mm$^3$, it may be preferable to defer PPV23 until after the CD4 count increases to greater than 200 cells/mm$^3$ on suppressive antiretroviral therapy. Revaccination with a dose of PPSV23 should occur at least 5 years after the first dose of PPSV23. If the person received their revaccination dose of PPSV23 prior to age 65, they should receive a third dose of PPSV23 after age 65 (and at least 5 years after the last dose of PPSV23).

- **Received One Prior Dose of PPSV23**: Adults with HIV who have already received one dose of PPSV23 (but no dose of PCV13) should receive one dose of PCV13 (at least 1 year after PPSV23). Revaccination with a dose of PPSV23 should be administered at least 5 years after the first dose of PPSV23 and at least 8 weeks after the PCV13 dose. If the individual has received two doses of PPSV23 prior to age 65, they should receive a third PPSV23 dose after age 65 and at least 5 years after the prior dose of PPSV23.

- **Received Two Prior Doses of PPSV23**: Adults with HIV who have already received two doses of PPSV23 (but no dose of PCV13) should receive one dose of PCV13 (at least 1 year after the last dose of PPSV23). If the individual has received the two doses of PPSV23 prior to age 65, they should receive a third dose of PPSV23 after age 65 and at least 5 years after the prior dose of PPSV23 (and at least 8 weeks after the PCV13 dose).

- **Received Prior Dose of PPSV23 after Age 65**: Adults with HIV who have already received two doses of PPSV23 prior to age 65 and one dose after age 65 (but no dose of PCV13) should receive one dose of PCV13 (at least 1 year after the last dose of PPSV23).

- **Persons 65 and Older**: All persons with HIV who have received PPSV23 prior to age 65 should receive one additional dose of PPSV23 at age 65, or later, but this must be given at least 5 years after the last dose of PPSV23 and at least 8 weeks after a dose of PCV13.
Tetanus, Diphtheria and Pertussis (Tdap) Vaccine

Background

Tetanus, diphtheria, and pertussis are vaccine-preventable bacterial diseases that can lead to serious complications. Tetanus (lockjaw) can potentially cause muscle paralysis and carries a 20% mortality rate. Diphtheria causes a thick coating to form in the posterior pharynx that can lead to breathing difficulty, and, in some instances, death. Pertussis (whooping cough) causes severe coughing spells that can lead to pneumonia, hypoxia, sleeping problems, and rarely death. Widespread childhood vaccination has markedly reduced the number of serious complications related to tetanus, diphtheria, and pertussis in the United States among all age groups. Although pertussis vaccine has reduced the incidence of pertussis compared with the pre-vaccine era, the number of reported cases of pertussis has increased since the 1980s, primarily due to lack of long-term immunity with the pertussis vaccine.[68] In recent years, the ACIP has recommended expanding the use of Tdap to improve community immunity against pertussis and reduce the burden of disease among the general population.[68] Most individuals with HIV mount adequate antibody responses to tetanus and diphtheria toxins, though it is a T-cell dependent vaccine and the titers are often lower among those with CD4 count less than 300 cells/mm³.[8,69]

Vaccines

Several tetanus and diphtheria toxoid vaccines (Td) are currently licensed by the FDA.[68] In addition, two tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccines are approved by the FDA: Boostrix (for persons aged 10 and older) and Adacel (for persons aged 11 to 64 years). Both the Tdap and Td vaccines contain inactivated bacteria and thus are unlikely to pose any risk to individuals with HIV infection. When the Tdap vaccine was initially licensed, concern existed regarding the safety of administering the Tdap vaccine within 5 years of the Td vaccine. Subsequently, studies reported that administering the Tdap to an individual who had recently received Td (21 days to 2 years) was safe, other than a mild local reaction.[68,70]

Recommendations

The following summarizes the 2020 ACIP Adult Immunization Schedule for administering Tdap and Td for adults with HIV.[1]

- **General Approach**: Adults with HIV should receive immunization with Tdap and Td per the same schedule as non-pregnant adults without HIV.[1] The timing and dosing of the Tdap and Td vaccination in persons with HIV is not altered based on CD4 count.
- **No Prior Tdap**: For adults with HIV who have not previously received Tdap, give a one-time dose of Tdap, followed by aTd or Tdap booster every 10 years.[1] Adults who previously received Td but have not had a Tdap dose should receive the Tdap vaccine regardless of the interval since Td was last administered.
- **Tdap for Pregnant Women with HIV**: Give Tdap during every pregnancy to prevent pertussis morbidity and mortality in infants. The dose of Tdap should be given preferably during gestational weeks 27 to 36 and it should be administered regardless of the pregnant woman’s prior history of receiving Tdap.[1]
Varicella Vaccine

Background

Varicella-zoster virus (VZV), or the chickenpox virus, is a highly contagious virus that causes rash, fever, and potentially severe, disseminated disease in persons with weakened immune systems. Prior to the introduction of the varicella vaccine and the incorporation of this vaccine into the routine childhood immunization schedule, chickenpox was very common in the United States general population, causing infection in more than 4 million persons each year. Primary varicella zoster virus infection is uncommon in adults with HIV since most have acquired immunity through childhood infection.[71]

Vaccine

The varicella vaccine is a live attenuated vaccine that poses significant risk to persons with HIV who have advanced immunosuppression. The duration of protection from varicella vaccine is not known. In addition to providing protection against primary varicella infection, the varicella vaccine has also been shown in studies to reduce the risk of herpes zoster (when compared with wild-type infection).[72,73]

Recommendations

The following summarizes the 2020 ACIP Adult Immunization Schedule and the Adult and Adolescent Opportunistic Infection Guidelines recommendations for administering varicella vaccine to adults with HIV.[1,71]

- **General Approach**: Adults with HIV and no evidence of immunity to VZV and a CD4 count of 200 cells/mm$^3$ or greater should receive varicella vaccine. The vaccine does not need to be given to those born in the United States before 1980, or to those with VZV immunity.
- **Dosing Recommendation**: Two doses of varicella vaccine should be given 3 months apart.
- **Contraindications**: Varicella vaccine is contraindicated in persons with HIV who have a CD4 count less than 200 cells/mm$^3$. In addition, the quadrivalent measles, mumps, rubella, and varicella vaccine is not recommended for individuals with HIV. The zoster vaccine should not be used interchangeably with the varicella vaccine, since the zoster vaccine has a much higher titer of live, attenuated VZV.
Zoster Vaccine

Background

Although primary varicella-zoster virus infection is unusual in persons with HIV, the incidence of zoster among adults with HIV is 15-fold higher than among age-matched immunocompetent adults, and the risk is highest in persons with a CD4 count less than 200 cells/mm$^3$.[71] Individuals with HIV have additional increased risk in the first 4 months after starting effective antiretroviral therapy, likely as a result of immune reconstitution.[74] Following the widespread use of potent antiretroviral therapy, the incidence rate of zoster has markedly decreased compared with early years of the HIV epidemic.[75] Zoster is typically limited to a painful, dermatomal vesicular rash but can result in severe and complicated disease in adults with HIV, especially those with a low CD4 count.[76] The goal of using zoster vaccine in persons with HIV is twofold: prevent zoster and reduce the severity of zoster if it does occur.

Zoster Vaccines

Recombinant Zoster Vaccine (RZV)

This recombinant zoster vaccine (RZV) contains varicella-zoster glycoprotein E combined with a novel adjuvant (AS01B) (Figure 8).[77,78] The RZV is licensed as a 2-dose vaccine series, given 2 to 6 months apart, for persons 50 years of age and older.[78] The ACIP also recommends RZV for adults who are 50 years of age and older and it is considered the preferred zoster vaccine.[1,78] The RZV has shown efficacy of greater than 95% in preventing herpes zoster in phase 3 trials that enrolled immunocompetent older adults.[79,80,81] In addition, a phase 1/2a trial evaluated RZV in persons with HIV and found that it was safe and immunogenic; this trial, however, did not evaluate the impact of RZV in preventing zoster.[82] Giving RZV to persons who previously received ZVL may provide significant benefit; the minimum acceptable interval between giving RZV to a person who previously received ZVL is 2 months. The RZV does not contain live varicella-zoster virus and therefore poses no risk of causing varicella-zoster infection.

Zoster Vaccine Live (ZVL)

The live attenuated zoster (shingles) vaccine, which is now referred to as zoster vaccine live (ZVL), is a live virus vaccine that contains high titers of varicella-zoster virus.[78] The ZVL is currently licensed in the United States for the prevention of shingles in adults over age 50, but the ACIP recommends use only in adults 60 years of age and older. This vaccine requires only one dose given subcutaneously and it requires freezing for storage.[78] In a study involving 296 adults with HIV and a CD4 count of at least 200 cells/mm$^3$, two doses of ZVL was safe and immunogenic.[83]

Recommendations

The 2020 ACIP Adult Immunization Schedule recommends the following for zoster vaccine in persons with HIV.[1]

- The RZV vaccine is preferred over the ZVL vaccine.
- For the use of RZV vaccine, there is a “no recommendation/not-applicable” (at all CD4 cell counts).
- For ZVL, it is not recommended for persons who have a CD4 count less than 200 cells/mm$^3$; there is a “no recommendation/not applicable” for the use of ZVL in persons with a CD4 count of 200 cells/mm$^3$ or greater.

The following summarizes recommendation from the Adult and Adolescent Opportunistic Infection Guidelines for use of RZV and ZVL in persons with HIV.[71]

- The RZV vaccine is preferred over the ZVL vaccine.
• The RZV is recommended for adults with HIV who are 50 years of age or older, regardless of CD4 cell count.
• The RZV vaccine should not be given during an episode of acute herpes zoster.
• To maximize immunologic response to RZV, some experts would defer administering RZV until virologic suppression on antiretroviral therapy has been achieved or until CD4 count recovery has occurred.
• The ZVL vaccine is contraindicated for persons with CD4 count less than 200 cells/mm$^3$. 
Travel Vaccines

Background

An estimated 8% of travelers to the resource-limited regions of the world require treatment during travel, and major disease risks include vaccine-preventable illnesses.[84] Vaccines related to travel are generally not part of the initial evaluation process of persons with HIV. Newly diagnosed, treatment-naïve individuals with CD4 counts less than 200 cells/mm$^3$ should delay travel until CD4 counts have been reconstituted with antiretroviral therapy in order to avoid immune reconstitution illness while traveling.[84] Many persons with HIV will eventually travel to regions of the world that require multiple preventive vaccinations, such as typhoid fever, cholera, yellow fever virus, Japanese encephalitis virus, and rabies virus. Recommendations for appropriate travel-related vaccines can be very complex and depend on numerous factors, including the immune status of the person with HIV, the specific region of travel, and the types of exposure likely to occur in that region.[85]

Recommendations

All persons with HIV infection who are planning international travel should undergo an evaluation by a medical provider who has expertise in travel-related issues, and this travel evaluation should occur well in advance of the travel date to allow time for all appropriate immunizations to be given. The CDC provides an online resource for general information regarding HIV and travel.[85,86]
Contraindicated Vaccines

Background

In general, caution should be exerted when administering any live virus vaccine to any immunocompromised individual, including persons with HIV. Certain live vaccines—Bacillus Calmette Guérin (BCG), vaccinia (smallpox), typhoid (21a) and live intranasal influenza—are contraindicated for all persons with HIV, regardless of CD4 cell count. In many resource-poor settings, BCG continues to be routinely administered to the general population in an effort to reduce the risk of tuberculosis infection. Unfortunately, persons with HIV who receive BCG as part of a general population vaccine program are at risk for subsequently developing disseminated vaccine-related tuberculosis, even years after receiving the vaccine.[87] The CDC recommends against the use of BCG for persons with HIV. Vaccinia immunization confers protection against smallpox and is still recommended for lab or healthcare workers who come into contact with the virus or attenuated strains through cultures or contact with infected animals or contaminated materials. Due to case reports of severe smallpox infection in persons with HIV after exposure to smallpox vaccine, the ACIP recommends against smallpox vaccination in persons with HIV in all non-emergency situations.[88]

Recommendations

The 2013 IDSA Vaccine Guidelines for the Immunocompromised Host recommends the following regarding use of live vaccines for adults and adolescents with HIV:[2]

- Live influenza vaccine is contraindicated, at any CD4 cell count.
- Quadrivalent measles, mumps, rubella and varicella vaccine is contraindicated regardless of CD4 count.
- Measles, mumps and rubella (MMR) and varicella vaccines are contraindicated with a CD4 count less than 200 cells/mm$^3$, but indicated for a non-immune individual with a CD4 count of 200 cells/mm$^3$ or greater.
- Zoster vaccine live (ZVL) is contraindicated for persons with HIV who have a CD4 count less than 200 cells/mm$^3$. 
Summary Points

- Adults with HIV should receive immunizations based on recommendations in the updated ACIP Adult Immunization Schedule and the Adult and Adolescent Opportunistic Infection Guidelines.
- Immune responses to vaccinations among persons with HIV are enhanced when the vaccines are given as early as possible in the course of HIV, or after immune reconstitution has occurred as a result of suppressive antiretroviral therapy.
- Vaccination is generally safe in persons with HIV, with the exception that live virus vaccines in persons with a CD4 count less than 200 cells/mm$^3$ can cause serious infectious complications.
- Hepatitis A vaccine is recommended for all persons with HIV are not immune to HAV.
- When giving the hepatitis B vaccine to adults with HIV, options with Engerix-B or Recombivax-HB include use of standard vaccine dose using a 3-dose schedule or double dose vaccine using a four-dose schedule. Postvaccination antibody titers should be checked 1 to 2 months after completion of the primary hepatitis B vaccine series.
- Three doses of 9vHPV should be administered to all persons with HIV age who are 9 through 26 years of age. The HPV vaccine is not recommended for persons with HIV who are 27 through 45 years of age.
- All adults with HIV should receive two doses of conjugate meningococcal vaccine and booster doses every 5 years thereafter.
- MMR and varicella vaccines are indicated for asymptomatic persons with HIV who have a CD4 count greater than 200 cells/mm$^3$ if they lack immunity to these vaccine-preventable illnesses.
- Pneumococcal vaccine-naïve persons should receive both the conjugate 13-valent (PCV13) and the 23-valent polysaccharide pneumococcal vaccine (PPSV23), and the recommended sequence and spacing of these vaccines depends on whether the individual has previously received any doses of polysaccharide pneumococcal vaccine.
- The recombinant zoster vaccine (RZV) is preferred over zoster vaccine live (ZVL). Two doses of RZV are recommended for persons with HIV who are 50 years of age and older. The ZVL should be avoided in persons who have a CD4 count below 200 cells/mm$^3$ due to the risk of developing disseminated varicella-zoster virus infection.
- Persons with HIV who plan to travel outside the United States should undergo an evaluation by a medical provider who has expertise in travel-related issues well in advance of planned travel.
Citations

   [PubMed Abstract] -

   [PubMed Abstract] -

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   [PubMed Abstract] -

   [PubMed Abstract] -

   [PubMed Abstract] -

   [PubMed Abstract] -

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[PubMed Abstract] -


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[PubMed Abstract] -


[AIDSinfo] -


[PubMed Abstract] -


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[PubMed Abstract]

[PubMed Abstract]

[PubMed Abstract]

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[MMWR]

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[PubMed Abstract] -

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[PubMed Abstract] -

[PubMed Abstract] -

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[PubMed Abstract] -

[MMWR] -

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[PubMed Abstract] -

[PubMed Abstract] -


- Tomczyk S, Bennett NM, Stoecker C, et al. Use of 13-Valent Pneumococcal Conjugate Vaccine and 23-Valent Pneumococcal Polysaccharide Vaccine Among Adults Aged ≥65 Years: Recommendations of
[MMWR] -

[PubMed Abstract] -
Figures

Figure 1 Production of Human Papillomavirus Subunit Vaccine

Conceptual rendition of production of human papillomavirus vaccine. The vaccine process involves recombinant synthesis of major capsid L1 proteins that self-assemble as a shell of 72 pentameric capsomers to form viral-like particles (VLPs). The assembled pseudovirus is very similar to the native human papillomavirus and is highly immunogenic.

Illustration by David H. Spach, MD
*Twinrix contains also contains 720 ELISA units of inactivated hepatitis A virus. Twinrix can be given on an accelerated schedule but this requires 4 doses (days 0, 7, and 21 to 30 followed by a booster dose at 12 months). These schedules and ratings are based on recommendations in the Adult and Adolescent Opportunistic Infections Guidelines.

Source: Panel on Opportunistic Infections in Adults and Adolescents with HIV. Guidelines for the prevention and treatment of opportunistic infections in adults and adolescents with HIV: recommendations from the Centers for Disease Control and Prevention, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. Hepatitis B virus infection. Last Updated: November 13, 2018.

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**SD** = standard dose<br>**HD** = high dose
Figure 3 Approach to Isolated Anti-HBc in Persons with HIV

This approach is based on recommendations in the Adult and Adolescent Opportunistic Infections Guidelines.

Source: Panel on Opportunistic Infections in Adults and Adolescents with HIV. Guidelines for the prevention and treatment of opportunistic infections in adults and adolescents with HIV: recommendations from the Centers for Disease Control and Prevention, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. Hepatitis B virus infection. Last Updated: November 13, 2018.
Figure 4 Number of Measles Cases in United States, Reported by Year, 2010-2019*

*The data for 2019 are through July 11.

Source: Centers for Disease Control and Prevention
Figure 5 *Neisseria meningitidis* Isolates in Persons with HIV—United States, 1995-2014

Figure 6 Serotypes in the Pneumococcal Conjugate Vaccine 13 (PCV13)

Figure 7 Recommendations for Pneumococcal Immunization in Adults with HIV Infection

Note green rectangles indicate administer PCV13 and dark blue rectangles indicate administer PPSV23. Light blue rectangles indicate prior receipt of PPSV23.

Figure 8 Herpes Zoster Vaccines

Varicella-Zoster Virus (VZV)

Attenuated VZV

Zoster Vaccine Live (ZVL)

Recombinant Zoster Vaccine (RZV)

Glycoprotein E

AS01B Adjuvant

Illustration by David H. Spach, MD
Table 1.

Vaccines in the Adult Immunization Schedule

<table>
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<tr>
<th>Vaccines</th>
<th>Abbreviations</th>
<th>Trade Names</th>
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<td>ActHIB, Hiberix</td>
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<td>HepB</td>
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<td>HPV vaccine</td>
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<td>Many brands</td>
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<td>Influenza vaccine, recombinant</td>
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<td>Flublok Quadrivalent</td>
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<td>MenB-4C, MenB-FHbp</td>
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Source:

- Centers for Disease Control and Prevention. Vaccines in the Adult Immunization Schedule. [CDC]
## Table 2.

### 2020 ACIP Recommended Immunizations for Adults with HIV

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<th>Vaccines</th>
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*This table is based on the 2020 ACIP Recommended Adult Immunization Schedule by Medical Condition and Other Indications, United States.

* Recommended if CD4 count greater than 200 cells/mm³ for at least 6 months with no evidence of immunity to measles, mumps, or rubella

* The dosing of PCV13 and PPSV23 depend on whether the person has previously received any doses of PPSV23 and whether the individual is younger than age 65 years.
<table>
<thead>
<tr>
<th>Vaccines</th>
<th>Abbreviations</th>
<th>CD4 count &lt;200 cells/mm³</th>
<th>CD4 count ≥200 cells/mm³</th>
</tr>
</thead>
</table>

**Source:**
