Published in final edited form as:

J Assoc Nurses AIDS Care. 2015 ; 26(2): 201–207. doi:10.1016/j.jana.2014.11.006.

An Immunization Update for HIV-infected Adults in the United States: Review of the literature

Patricia A. Cioe, PhD, APRN, FNP-BC [Assistant Professor],

Center for Alcohol and Addiction Studies, Brown University School of Public Health, Providence, Rhode Island, USA

Kathleen Melbourne, PharmD [Director of HIV Medical Sciences], and

Gilead Sciences, Foster City, California, USA

Jerome Larkin, MD [Assistant Professor of Medicine]

Department of Infectious Disease, Brown University, Providence, Rhode Island, USA

Keywords

HIV; immunizations; vaccines

Persons living with HIV infection (PLWH) are experiencing near normal lifespans due to the advances in antiretroviral treatment (ART) that have taken place over the past 30 years. In fact, it is estimated that more than half of PLWH in the United States will be greater than 50 years of age by 2015 (Effros et al., 2008). This transformation from acute and often fatal disease to a chronic, though complex, illness in the United States offers clinicians the opportunity to direct greater attention to the primary care needs of an aging HIV-infected population.

Reducing the incidence of vaccine-preventable diseases is one area of focus for clinicians in this new era of HIV infection management. The administration of safe, timely, and effective immunizations is the most effective method to avoid preventable diseases in PLWH. Nurses have a key role in this effort because they are likely to have contact with PLWH who have increased risk for and severity of illness due to their compromised immune function. Being aware of the most current guidelines for vaccine administration is of key importance. The purpose of this brief is to present an overview of the current immunization guidelines for adults living with HIV infection in the United States (See Table 1). We also provide a comprehensive summary of the evidence-based literature related to the safety and durability associated with the use of each vaccine (where available) for this population of patients.

Corresponding Author: Patricia A. Cioe, Patricia_Cioe@brown.edu.

Conflict of Interest Statement: The authors report no real or perceived vested interests that relate to this article that could be construed as a conflict of interest. Kathleen Melbourne is an employee of Gilead Sciences.

Recommended Vaccines for HIV-Infected Adults

Influenza

In the U.S. general population, influenza has been associated with an estimated 36,000 deaths each year (Durham et al., 2011). In PLWH, influenza infection may have an increased severity of symptoms and be of a prolonged duration when compared with the general population (Kunisaki & Janoff, 2009). While vaccination has been shown to be safe and effective for the prevention of influenza infection in PLWH, there is limited evidence that vaccination lowers the risk of all-cause pneumonia, hospitalization, or mortality (Remschmidt, Wichmann, & Harder, 2014). In fact, the mortality rate in PLWH due to influenza is 10-fold higher compared with the HIV-uninfected population (Valour et al., 2014).

Current guidelines recommend that all PLWH receive an annual inactivated influenza vaccine, regardless of their immune status, as soon as the vaccine becomes available each year (Rubin et al., 2014). Despite this recommendation, influenza vaccination coverage remains low. In the HIV Outpatient Study (HOPS study), an ongoing prospective observational cohort study of U.S. patients, annual influenza vaccination rates ranged from 25.8% to 43.3% (Durham et al., 2011), while a French study of nearly 2,500 patients found only 30% influenza vaccine coverage (Valour et al., 2014). Clearly, increased efforts are needed to improve coverage of this susceptible population.

While some clinicians have speculated that vaccination later in the influenza season in PLWH may be more effective at limiting late-season infections, delaying vaccination is not currently recommended (Crum-Cianflone & Wallace, 2014). Influenza can occur early in the season, and a delay may lead to missed opportunities for vaccination. In the general population, influenza vaccine is considered durable throughout the entire flu season, but durability data are lacking for PLWH (Crum-Cianflone & Wallace, 2014). Revaccination of PLWH later in the season to address potential waning immunity from the first administered dose may, in theory, offer benefit but there are currently no data to support such a strategy (Crum-Cianflone & Wallace, 2014).

Pneumococcal Disease

Community-acquired pneumonia is often caused by infection with *Streptococcus pneumoniae* (pneumococcus), an invasive pneumococcal disease (IPD); meningitis and bacteremia that can result as a complication of primary infection are important health problems in PLWH (Grau et al., 2005). Risk factors for IPD include cigarette smoking, alcohol dependence, history of hospitalization, and low CD4+ T-cell count (< 100 cells/mm³; Grau et al., 2005). Despite advances in treatment, the mortality rate due to bacteremic pneumococcal pneumonia in the general population is high (12%), and PLWH have a markedly increased risk of IPD with a 2-fold higher mortality rate (Grau et al., 2009; Yin et al., 2012).

All patients with a CD4+ T-cell count greater than 200 cells/mm³ should receive both pneumococcal 13-valent conjugate vaccine (PCV13; Prevnar13[®]) and 23-valent polysaccharide vaccine (PPV23; Pneumovax[®]). PCV13 should be administered first

followed by PPV23 in 8 or more weeks. A booster dose of PCV23 should be given 5 years after the first PPV 23. If a patient has previously received PPV23, immunization with PCV13 should be delayed by 1 year (Aberg et al., 2014).

Hepatitis A

Hepatitis A virus (HAV) is an acute, typically self-limited viral infection of the liver with a fecal-oral route of transmission. PLWH may experience higher and more prolonged viremia during acute infection, which may in turn lead to a greater number of secondary cases (Ida et al., 2002). PLWH have higher mortality rates from HAV infection, especially if they are co-infected with hepatitis B or C (Kourkounti, Papaizos, Leuow, Kordosis, & Antoniou, 2013).

Risk factors for hepatitis A infection include men who have sex with men, injection drug use, previous infection with hepatitis B or C, and travel to HAV high-prevalence countries (Bridges & Coyne-Beasley, 2014). Although previously recommended for those with risk factors for HAV infection, hepatitis A vaccination is now recommended for all non-immune patients (identified by a negative anti-HAV antibody; Aberg et al., 2014). Following the administration of two doses of hepatitis A vaccine (6-12 months apart), antibody testing for hepatitis A total or IgG antibody should be obtained to assess for immune response. Antibody testing can be performed 1–2 months after the second vaccine dose or at the next scheduled office visit. Patients who remain seronegative should receive a second vaccine series. The immune response to HAV vaccine among PLWH has been shown to be similar in both ART-treated and ART-naïve patients (78% vs. 76%), and was not found to differ between those with CD4+ T-cell counts of 200–499 cells/mm³ and those with CD4+ T-cell counts greater than 500 cells/mm³ (71% vs. 80%, $p > 0.05$; Kourkounti et al., 2013). The response to HAV vaccine is considered durable in PLWH; one study found that, following two doses of vaccine, 82% and 75.5% of patients had detectable antibody to HAV at 1 year and 5 years, respectively (Jabłonowska & Kuydowicz, 2014). Likewise, a meta-analysis found that HAV vaccine response durability was noted in 85% of vaccinated adults at 4 years (Kerneis et al., 2014).

Hepatitis B

Hepatitis B (HBV) is a viral infection of the liver; primary infection results in either the development of immunity or a chronic active form of disease. Liver disease due to chronic active hepatitis B has become a leading cause of morbidity and mortality in PLWH (Thio et al., 2002). Although only about 15% of those exposed to the virus develop chronic infection, such patients are at risk of developing cirrhosis, hepatocellular carcinoma, and end stage liver disease (Clifford et al., 2008). Screening for evidence of prior HBV infection is currently recommended for all PLWH upon entry into care by testing for hepatitis B surface antigen (HBsAg), hepatitis surface antibody (HBsAb), and antibody to hepatitis B core antigen (HBcAb; Aberg et al., 2014).

Patients who do not have evidence of prior immunity to HBV should be vaccinated against the virus. The HBV vaccination series includes three injections at 0, 1, and 6 months. To assess for immune response to the vaccination series, HBsAb should be obtained 1–2 months following completion of the series. It is recommended that the series of three

vaccines be administered a second time if the HBsAb level is negative or less than 10 IU/mL after the primary series of HBV vaccine is administered (Aberg et al., 2014). Patients who are negative for HBsAg and HBsAb but positive for anti-HBc should be screened for chronic HBV infection by determination of HBV viral DNA, and those without evidence of chronic infection should be considered for vaccination. A major challenge to adequate coverage against HBV in PLWH is completion of the vaccine series. Establishment of a specialized vaccine clinic and use of text message reminders for vaccination have been shown to improve completion rates in PLWH (Rock et al., 2013).

Human Papilloma Virus

With approximately 14 million new infections reported each year in the United States, human papillomavirus (HPV) has become the most common sexually transmitted infection affecting both men and women (Satterwhite et al., 2013). Although more than 150 strains of HPV have been identified, 13 are considered high-risk strains and are the primary cause of HPV-related cancers. Most cervical cancers are caused by high-risk strains 16 and 18 (Walboomers et al., 1999), while other strains (HPV 6 and 11) are non-oncogenic types that may cause genital warts and respiratory papillomatosis in both males and females (Markowitz et al., 2014; Sun, Chang, & Rutherford, 2013).

The clinical concern with this mostly asymptomatic and often self-limited infection is persistent infection, which may lead to cervical, vaginal, or vulvar cancer in women, and anal, penile, or oropharyngeal cancer in men (Sun et al., 2013). PLWH are at increased risk for both HPV infection and HPV-related cancers (Sun et al., 2013), with cervical lesions in HIV-infected women being four times more prevalent compared to uninfected counterparts (Massad & Markwell, 2004). The majority of anal dysplasia and cancer in PLWH occurs in HIV-infected men who have sex with men (Cachay & Mathews, 2014), and the incidence of anal cancer is 42 times higher in PLWH compared to the general population (Sun et al., 2013).

Current guidelines regarding HPV vaccines in HIV-infected adults follow the recommendations of the Advisory Committee on Immunization Practices (Aberg et al., 2014). Two HPV vaccines are available in the United States for use in women and men, including PLWH: the bivalent HPV vaccine (HPV2, Cervarix[®], which covers HPV 16 and 18) and the quadrivalent HPV vaccine (HPV4, Gardasil[®], which covers HPV 6, 11, 16, and 18). Routine vaccination is recommended at age 11 or 12 years with HPV2 or HPV4 for females and with HPV4 for males through age 26, specifically focusing on MSM (Bridges & Coyne-Beasley, 2014; Markowitz et al., 2014). There is a 3-dose schedule for both HPV4 and HPV2 vaccines, with doses administered at baseline, 1-2 months, and 6 months (Markowitz et al., 2014).

Tetanus, Diphtheria, Pertussis

Tetanus is an infection caused by the bacterium *Clostridium tetani* that affects the nervous system, causing painful muscle contractions, often in the jaw and neck muscles. Symptoms may include headache, trismus (lockjaw), dysphagia, and neck stiffness (Centers for Disease Control and Prevention [CDC], 2014; Giordano et al., 2014). Diphtheria is a bacterial

infection (caused by *Corynebacterium diphtheria* organism) that affects the upper respiratory tract and causes symptoms of sore throat and fever (Atkinson, Hamborsky, McIntyre, & Wolfe, 2007). Pertussis, another upper respiratory infection, is caused by the bacterium *Bordetella pertussis* and is commonly known as whooping cough (CDC, 2014). In the United States, these cases are fairly rare in adults due to the effectiveness of the tetanus (Td) and tetanus-diphtheria-pertussis vaccines (Tdap).

All PLWH should receive Tdap once regardless of the time since their most recent Td booster (Aberg et al., 2014). Thereafter, they should receive the Td vaccine every 10 years. In a prospective study of PLWH, Kroon, van Dissel, Labadie, van Loon, and van Furth (1995) concluded that the antibody response to tetanus vaccine by PLWH was comparable to uninfected populations (83-100%); however, response to the diphtheria vaccine was lower (61-73%) and varied by CD4+ T lymphocyte counts, with those having a CD4+ T-cell count greater than 300 cells/mm³ having a more robust response.

Varicella

Primary varicella infection (chicken pox) is an acute infection caused by the varicella zoster virus (VZV). Symptoms of primary infection include rash, fever, and malaise. Often seen during childhood, recovery from the primary infection leads to lifelong immunity (CDC, 2014). Patients who are immune compromised may develop disseminated disease during primary infection, with complications, including pneumonia and encephalitis. Primary infection in the immune-compromised patient is associated with a 25-fold greater estimated risk of death (CDC, 2014).

Varicella vaccination should be considered in HIV-infected adults in whom there is no previous history of varicella infection or who lack serologic evidence of prior disease (VZV-seronegative; Aberg et al., 2014). Because it is a live-virus vaccine, it is recommended only for those patients who have CD4+ T-cell counts greater than 200 cells/mm³.

Herpes Zoster

Herpes zoster (VZV) is caused by the reactivation of the varicella zoster virus following primary infection. It is common in the United States, with more than one million cases reported annually (Blank, Polydefkis, Moore, & Gebo, 2012). While most cases of zoster (also referred to as shingles) in the general population occur in adults 60 years of age and older, the infection can be seen in HIV-infected adults at any age and often is related to immune suppression (greatest risk at CD4+ T-cell counts < 350 cells/mm³) and during immune reconstitution following the initiation of ART (Blank et al., 2012). Zoster manifests as a painful skin rash limited to one dermatome of the body and usually resolves within 1-2 weeks. Residual neuropathic pain (post-herpetic neuralgia) can follow the rash and may persist for several months or years (CDC, 2014).

The VZV vaccine (Zostavax®) became available in 2006, but data regarding its safety and efficacy in HIV-infected adults are limited (Aberg et al., 2014). The administration of VZV vaccine may be considered in PLWH older than age 60 whose CD4+ T-cell counts are greater than 200 cells/mm³ and who have demonstrated immunity to varicella (history of

varicella or positive VZV IgG level). A study in adults living with HIV demonstrated that Zostavax[®] vaccine administered twice (doses given 6 weeks apart) was safe in those with CD4+ T cell counts greater than or equal to 200 cells/mm³ who were virologically suppressed on ART (Benson et al., 2012).

Additional Considerations

The likelihood of an antibody response to any vaccine in PLWH is variable, with optimal responses generally seen in patients with higher CD4+ T-lymphocyte cell counts and in those receiving suppressive ART (Aberg et al., 2014). It is generally recommended, therefore, that vaccines be administered at the time of HIV diagnosis or shortly thereafter (Aberg et al., 2014; Rubin et al., 2014). Other factors, such as poor nutrition and co-infection with hepatitis C, may also affect immune function and interfere with the response to vaccines (Bridges & Coyne-Beasley, 2014). Inactivated vaccines, such as influenza and hepatitis A and B, may be administered without regard for CD4+ T-lymphocyte counts (Rivas, Herrero, Puente, Ramirez-Olivencia, & Soriano, 2007). It has been suggested, however, that in some cases vaccination may be delayed until immune reconstitution has taken place in patients initiating ART (Rivas et al., 2007). Such a strategy should take into account a patient's individual ongoing risk of acquiring the disease.

Certain live vaccines, including measles-mumps-rubella (MMR), varicella, and zoster are recommended only for patients whose CD4+ T-lymphocyte counts are above 200 cells/mm³ (Rivas et al., 2007). Other live vaccines, including tuberculosis (BCG), intranasal influenza, smallpox, typhoid, yellow fever, and oral polio vaccines, are contraindicated in HIV-infected patients. The risk of some vaccine-preventable illnesses is, in certain cases, related to immune suppression (such as with zoster) and, therefore, highlights the importance of early HIV diagnosis, early initiation of ART, and timely restoration of immune function. Finally, one study demonstrated that being followed by an experienced HIV clinician appeared to be an independent predictor of vaccine receipt in PLWH (Valour et al., 2014).

Implications for Nursing

In summary, the administration of immunizations to HIV-infected adults is a critical component of primary care for an aging population of PLWH. Even with the development of effective and safe vaccines, vaccination rates often remain disappointingly low, especially considering the ability to avert vaccine-preventable illnesses in this susceptible population. Additional efforts are needed to improve immunization rates in HIV-infected adults. Nurses are in a pivotal position to assist in these efforts and play a key role in achieving improved rates of vaccination in PLWH.

Acknowledgments

This work was supported by grant number K23 NR014951-01A1 from the National Institute of Nursing Research at the National Institutes of Health (Dr. Cioe).

References

- Aberg JA, Gallant JE, Ghanem KG, Emmanuel P, Zingman BS, Horberg MA. Primary care guidelines for the management of persons infected with HIV: 2013 update by the HIV Medicine Association of the Infectious Diseases Society of America. *Clinical Infectious Diseases*. 2014; 58:e1–e34.10.1093/cid/cit665 [PubMed: 24235263]
- Atkinson, W.; Hamborsky, J.; McIntyre, L.; Wolfe, S., editors. *Epidemiology and prevention of vaccine-preventable disease*. 10th. Washington DC: Public Health Foundation; 2007. Diphtheria; p. 59-70.
- Benson, CA.; Hua, L.; Anderson, JW.; Jiang, JH.; Bozzolo, DR.; Bergstrom, K.; Lennox, J. Zostavax is generally safe and immunogenic in HIV+ adults virologically suppressed on ART: Results of a Phase 2, randomized, double-blind, placebo-controlled trial. CROI; 2012; Seattle, WA. 2012. Abstract 96
- Blank LJ, Polydefkis MJ, Moore RD, Gebo KA. Herpes zoster among persons living with HIV in the current ART era. *Journal of Acquired Immune Deficiency Syndromes*. 2012; 6(2):203–207.10.1097/qai.0b013e318266cd3c [PubMed: 22766968]
- Bridges CB, Coyne-Beasley T. Advisory committee on immunization practices recommended immunization schedule for adults aged 19 years or older: United States, 2014. *Annals of Internal Medicine*. 2014; 160(3):190–197.10.7326/M13-2826 [PubMed: 24658695]
- Cachay ER, Mathews WC. Use of papillomavirus vaccine in HIV-infected men for the prevention of anal dysplasia and cancer. *AIDS Review*. 2014; 16(2):90–100.
- Centers for Disease Control and Prevention. Vaccines and immunizations. 2014. Retrieved from <http://www.cdc.gov/vaccines>
- Clifford GM, Rickenbach M, Polesel J, Dal Maso L, Steffen I, Ledergerber B, Franceschi S. Influence of HIV-related immunodeficiency on the risk of hepatocellular carcinoma. *AIDS*. 2008; 22:2135–2141.10.1097/QAD.0b013e32831103ad [PubMed: 18832877]
- Crum-Cianflone NF, Wallace MR. Vaccination in HIV-infected adults. *AIDS Patient Care and STDs*. 2014; 28(8):397–410. [PubMed: 25029589]
- Durham MD, Buchacz K, Armon C, Patel P, Wood K, Brooks JT. Rates and correlates of influenza vaccination among HIV-infected adults in the HIV Outpatient Study (HOPS), USA, 1999-2008. *Preventive Medicine*. 2011; 53:89–94.10.1016/j.ypmed.2011.04.015 [PubMed: 21569791]
- Effros RB, Fletcher CV, Gebo K, Halter JB, Hazzard WR, Horne FM, High KP. Aging and infectious diseases: Workshop on HIV infection and aging: What is known and future research directions. *Clinical Infectious Diseases*. 2008; 47:542–553.10.1086/590150 [PubMed: 18627268]
- Giordano M, Ciarambino T, DiBella O, Finelli A, Ferrara N, Paolisso G. Acute dysphagia in an octogenarian: An unusual case of tetanus. *American Journal of Emergency Medicine*. 2014; 32(6): 691, e1–2.10.1016/j.ajem.2013.12.020 [PubMed: 24468126]
- Grau I, Pallares R, Tubau F, Schulze HM, Llopis F, Podzamczar D, Gudiol F. Epidemiologic changes in bacteremic pneumococcal disease in patients with HIV in the era of HAART. *Archives of Internal Medicine*. 2005; 165:1533–1540.10.1001/archinte.165.13.1533 [PubMed: 16009870]
- Grau I, Ardanuy C, Linares J, Podzamczar D, Schulze MH, Pallares R. Trends in mortality and antibiotic resistance among HIV-infected patients with invasive pneumococcal disease. *HIV Medicine*. 2009; 10:488–495.10.1111/j.1468-1293.2009.00717.x [PubMed: 19459987]
- Ida S, Tachikawa N, Nakajima A, Daikoku M, Yano M, Kikuchi Y, Oka S. Influence of human immunodeficiency virus type 1 infection on acute hepatitis A virus infection. *Clinical Infectious Diseases*. 2002; 34:379–385.10.1086/338152 [PubMed: 11774086]
- Jabłowska E, Kuydowicz J. Durability of response to vaccination against viral hepatitis A in HIV-infected patients: A 5-year observation. *International Journal of STD and AIDS*. 2014; 25(10): 745–750.10.1177/0956462413518902 [PubMed: 24452731]
- Kerneis S, Launay O, Turbelin C, Batteux F, Hanslik T, Boelle P. Long-term immune responses to vaccination in HIV-infected patients: A systematic review and meta-analysis. *Clinical Infectious Diseases*. 2014; 58(8):1130–1139.10.1093/cid/cit937 [PubMed: 24415637]

- Kourkounti S, Papaizos V, Leuow K, Kordosis T, Antoniou C. Hepatitis A vaccination and immunological parameters in HIV-infected patients. *Viral Immunology*. 2013; 26(5):357–363.10.1089/vim.2012.0100 [PubMed: 24044625]
- Kroon FP, van Dissel JT, Labadie J, van Loon AM, van Furth R. Antibody response to diphtheria, tetanus, and poliomyelitis vaccines in relation to the number of CD4 +T lymphocytes in adults infected with human immunodeficiency virus. *Clinical Infectious Diseases*. 1995; 21:1197–1203.10.1093/clinids/21.5.1197 [PubMed: 8589143]
- Kunisaki KM, Janoff EN. Influenza in immunosuppressed populations: A review of infection frequency, morbidity, mortality, and vaccine responses. *Lancet Infectious Diseases*. 2009; 9:493–504.10.1016/S1473-3099(09)70175-6
- Markowitz LE, Dunne EF, Saraiya M, Chesson HW, Curtis CR, Gee J, Unger ER. Human papillomavirus vaccination: Recommendations of the Advisory Committee on Immunization Practices (ACIP). *Morbidity and Mortality Weekly Report*. 2014; 63(5):1–36. [PubMed: 24402465]
- Massad LS, Markwell S. Using patient history to predict high-grade cervical dysplasia and cancer in women with borderline cervical cytologic results. *Journal of Lower Genital Tract Diseases*. 2004; 8(3):207–211.10.1097/00128360-200407000-00008
- Remschmidt C, Wichmann O, Harder T. Influenza vaccination in HIV-infected individuals: Systematic review and assessment of quality of evidence related to vaccine efficacy, effectiveness and safety. *Vaccine*. 2014; 32:5585–5592.10.1016/j.vaccine.2014.07.101 [PubMed: 25131742]
- Rivas P, Herrero MD, Puente S, Ramirez-Olivencia G, Soriano V. Immunizations in HIV-infected adults. *AIDS Review*. 2007; 9:173–187.
- Rock C, deBarra E, Sadlier C, Kelly S, Dowling C, McNally C, Bergin C. Impact of a new vaccine clinic on hepatitis B vaccine completion and immunological response rates in an HIV-positive cohort. *Journal of Infection and Public Health*. 2013; 6:173–178.10.1016/j.jiph.2012.11.001 [PubMed: 23668461]
- Rubin LG, Levin MJ, Ljungman P, Davies EG, Avery R, Tomblyn M, Kang I. 2013 IDSA clinical practice guideline for vaccination of the immunocompromised host. *Clinical Infectious Diseases*. 2014; 58:309–318.10.1093/cid/cit684 [PubMed: 24421306]
- Satterwhite CL, Torrone E, Meites E, Dunne EF, Mahajan R, Ocfemia MC, Weinstock H. Sexually transmitted infections among US women and men: Prevalence and incidence estimates, 2008. *Sexually Transmitted Diseases*. 2013; 40:187–193.10.1097/OLQ.0b013e318286bb53 [PubMed: 23403598]
- Sun V, Chang L, Rutherford GW. Human papilloma virus (HPV) vaccine for individuals with HIV infection (Protocol). *Cochrane Database System Reviews*. 2013; 4:1–8.
- Thio CL, Seaberg EC, Skolasky R, Phair J, Visscher B, Munoz A, Thomas DL. HIV-1, hepatitis B virus, and risk of liver-related mortality in the Multicenter Cohort Study (MACS). *Lancet*. 2002; 360:1921–1926.10.1016/S0140-6736(02)11913-1 [PubMed: 12493258]
- Valour F, Cotte L, Voirin N, Godinot M, Ader F, Ferry T, Chidiac C. Vaccination coverage against hepatitis A and B viruses, Streptococcus pneumonia, seasonal flu, and A(H1N1) 2009 pandemic influenza in HIV-infected patients. *Vaccine*. 2014; 32:4558–4564.10.1016/j.vaccine.2014.06.015 [PubMed: 24951870]
- Walboomers JM, Jacobs MV, Manos MM, Bosch FX, Kummer JA, Shah KV, Muñoz N. Human papillomavirus is a necessary cause of invasive cervical cancer worldwide. *Journal of Pathology*. 1999; 189:12–19. 189:1<12::AID-PATH431>3.0.CO;2-F. 10.1002/(SICI)1096-9896(199909) [PubMed: 10451482]
- Yin Z, Rice BD, Waight P, Miller E, George R, Brown A, Delpech VC. Invasive pneumococcal disease among HIV-positive individuals, 2000–2009. *AIDS*. 2012; 26:87–94.10.1097/QAD.0b013e32834dcf27 [PubMed: 22008657]

Table 1
Recommended Vaccines for HIV-infected Adults

Vaccine	Dose	Schedule	Comments
Influenza (IIV)	0.5 mL IM	Annually	All patients
Pneumococcal			
Prevnar13 (PCV13)	0.5 mL IM	Once	All patients
Pneumovax (PPV23)	0.5 mL IM	2 doses; 0 & 5 years	8 weeks after PCV13 or when CD4+ T cell count ≥ 200 cells/mm ³
Hepatitis A	1 mL	2 doses: 0 & 6-12 months	All non-immune (Anti-HAV - or IgG)
Hepatitis B	1 mL	3 doses: 0, 1, & 6 months	All non-immune patients (anti-HBs < 10mIU/mL)
HPV	0.5 mL	3 doses: 0, 1-2, & 6 months	Ideally give prior to onset of sexual activity. Males and females ages 9-26. Avoid use during pregnancy.
Tetanus toxoid			
Tdap	0.5-0.75 mL IM per PI	One dose during lifetime	Td may be given after 20 weeks gestation if pregnant
Td	0.5 mL IM	Every 10 years	
Varicella	0.5 mL IM	2 doses: 0 & 3 months	Non-immune patients (VZV IgG-) with CD4+ T cell count ≥ 200 cells/mm ³
Zoster		One dose	Consider in patients > age 60 with varicella immunity and CD4+ t cell count ≥ 200 cells/mm ³
Haemophilus influenza type B	0.5 mL IM	One dose	Consider in asplenic patients only
MMR	0.5 mL SQ	One dose	Only in non-immune patients with CD4+ T cell counts ≥ 200 cells/mm ³

Note. IIV = inactivated influenza vaccine; IM = intramuscular; PCV = pneumococcal conjugate vaccine; PPV = pneumococcal polysaccharide vaccine; anti-HAV = antibody to hepatitis A virus; Anti-HBs = antibody to hepatitis B surface antigen; HPV = human papillomavirus; Tdap = tetanus toxoid, reduced diphtheria toxoid; Td = tetanus toxoid and reduced diphtheria toxoid and acellular pertussis; PI = package insert; VZV = varicella zoster virus; MMR = measles-mumps-rubella vaccine; SQ = subcutaneous.