

Opportunistic Infections: Prevention

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Module 4: [Co-Occurring Conditions](#)

Lesson 2: [Opportunistic Infections: Prevention](#)

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<https://www.hiv.uw.edu/go/co-occurring-conditions/opportunistic-infections-prevention/core-concept/all>.

Background and Overview

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Despite the widespread availability and use of potent antiretroviral therapy, individuals with HIV continue to suffer significant morbidity and mortality from opportunistic infections, defined as infections that are more frequent or severe due to immunosuppression. The introduction of effective antiretroviral therapy in the mid-1990s led to a dramatic decline in the rate of AIDS-defining opportunistic infections in the United States ([Figure 1](#)), and these declines involved all major AIDS-defining opportunistic infections ([Figure 2](#)).^[1,2] During 2000 through 2010 (in the United States and Canada), AIDS-defining opportunistic infections occurred at a low rate and there were further declines during this decade ([Figure 3](#)).^[3] In the current era, the rate of AIDS-defining opportunistic infections has remained low. Nevertheless, these opportunistic infections can still occur in individuals with HIV, particularly in the setting of undiagnosed HIV, late diagnosis of HIV, or in persons with known HIV who are not engaged in care. Clinicians who provide care to persons with HIV should have basic competency in the prevention, diagnosis, and treatment of common AIDS-defining opportunistic infections. This Topic Review provides an overview of the prophylaxis of the most common and important opportunistic infections that occur in persons with HIV. The content is based on recommendations in the Adult and Adolescent OI Guidelines.^[4]

***Pneumocystis* Pneumonia**

Background

Pneumocystis pneumonia (PCP) is an important cause of morbidity and mortality in persons with HIV. *Pneumocystis* pneumonia is caused by *Pneumocystis jirovecii*, a ubiquitous organism that has been classified as a fungus. The previously used name *Pneumocystis carinii* is no longer used after a taxonomy reclassification when it became clear that *P. jirovecii* infects humans and *P. carinii* infects rats. Before the use of effective antiretroviral therapy and *Pneumocystis* pneumonia prophylaxis, PCP occurred in up to 80% of people with AIDS; the incidence among people with AIDS in the United States and Western Europe has declined to fewer than 1 case per 100 person-years.[2,3,5] *Pneumocystis jirovecii* is most likely transmitted via the airborne route and disease can occur by acquisition of a new infection or by reactivation of a latent infection. The risk of developing *Pneumocystis* pneumonia increases markedly with advanced immunosuppression and approximately 90% of individuals with PCP have a CD4 count less than 200 cells/mm³. [6,7]

Indications for Initiating Primary Prophylaxis

Prophylaxis is considered primary (preventing the first episode of *Pneumocystis* pneumonia) or secondary (preventing recurrence of *Pneumocystis* pneumonia). The Adult and Adolescent OI Guidelines recommend the following indications for initiating primary PCP prophylaxis.[8]

- CD4 count less than 200 cells/mm³ (**AI**), or
- CD4 percentage less than 14% cells/mm³ (**BII**), or
- CD4 count greater than 200 cells/mm³ but less than 250 cells/mm³ if antiretroviral therapy must be delayed and CD4 monitoring (e.g., every 3 months) is not possible (**BII**)

Note: Individuals receiving treatment for toxoplasmosis with pyrimethamine and sulfadiazine do not require additional *Pneumocystis* pneumonia prophylaxis (**AII**).[8,9]

Recommended Regimens for Primary Prophylaxis

The Adult and Adolescent OI Guidelines provide recommendations for preferred and alternative agents for *Pneumocystis* pneumonia primary prophylaxis (Table 1).[8]

- **Preferred Therapy:** Trimethoprim-sulfamethoxazole is the preferred agent for *Pneumocystis* pneumonia prophylaxis and studies have shown that either a double-strength tablet or a single-strength tablet taken daily is effective in preventing *Pneumocystis* pneumonia.[10,11,12]
- **Alternative Therapy:** If a patient cannot tolerate daily dosing of trimethoprim-sulfamethoxazole, there are several alternative regimens:[8,11]
 - Low-Dose Trimethoprim-Sulfamethoxazole: If a lower doses of trimethoprim-sulfamethoxazole is used, the recommended dosing is one double-strength tablet three times per week).[13,14]
 - Dapsone: For *Pneumocystis* pneumonia prophylaxis, dapsone has been used as different daily doses and as a weekly dose. Prior to starting dapsone once daily, it is necessary to check a glucose-6-phosphate dehydrogenase (G6PD) level since dapsone may trigger hemolytic anemia in patients who have G6PD deficiency.[11,13,15]
 - Atovaquone: Although atovaquone once daily has efficacy similar to dapsone and inhaled pentamidine for *Pneumocystis* pneumonia prophylaxis, it is considerably more expensive and available only as a liquid formulation.[15,16]
 - Inhaled Pentamidine: Aerosolized inhaled pentamidine is conveniently dosed once monthly, but it is contraindicated for use in persons with underlying reactive airway disease or pulmonary disease, penetrates poorly to the peripheral regions of the lung, lacks systemic protection against *P. jirovecii*, and must be administered in a clinic or hospital setting using a

special Respigard II nebulizer.[10,11,17]

- **Cross Protection Against *Toxoplasma* Encephalitis:** Use of daily double-strength trimethoprim-sulfamethoxazole provides effective primary prophylaxis for *Toxoplasma* encephalitis and is the preferred dose to use if *Toxoplasma* encephalitis prophylaxis is needed.[18] Several studies suggest lower doses of trimethoprim-sulfamethoxazole also provide adequate protection against *Toxoplasma* encephalitis.[13,19] Dapsone alone does not provide sufficient protection against *Toxoplasma* encephalitis and must be combined with pyrimethamine and leucovorin. The use of leucovorin with pyrimethamine is to prevent pyrimethamine-related bone marrow toxicity. Atovaquone is an alternative for *Toxoplasma* encephalitis primary prophylaxis, but some experts recommend adding pyrimethamine and leucovorin. Note that the exorbitant cost of pyrimethamine has limited its use in this setting.[20]

Discontinuing Primary Prophylaxis

Primary prophylaxis against *Pneumocystis* pneumonia should be discontinued when possible to reduce pill burden, minimize risk of toxicity and drug interactions, and prevent the selection of drug-resistant pathogens. The Adult and Adolescent OI Guidelines list the following indications for discontinuation of primary *Pneumocystis* pneumonia prophylaxis.[8]

- CD4 count increase from less than 200 cells/mm³ to 200 cells/mm³ or greater for at least 3 months in response to antiretroviral therapy (**AI**). This recommendation is based on multiple studies that have shown very low risk of developing *Pneumocystis* pneumonia if primary prophylaxis is discontinued after responding to antiretroviral therapy with a CD4 cell count increase to above 200 cells/mm³. [21,22,23]
- Can consider if CD4 count 100 to 200 cells/mm³ and HIV RNA levels remain below the limit of detection for at least 3 to 6 months (**BII**). This recommendation is based on primary data from several studies that reported a very low incidence of *Pneumocystis* pneumonia among individuals with a CD4 count between 100 and 200 cells/mm³ who stopped or never took *Pneumocystis* pneumonia prophylaxis if they had suppressed HIV RNA levels.[24,25,26]

Restarting Primary Prophylaxis

Primary prophylaxis for *Pneumocystis* pneumonia should be restarted if (1) the CD4 count declines to less than 100 cells/mm³ regardless of HIV RNA level or (2) if the CD4 count is 100 to 200 cells/mm³ and the HIV RNA is detectable.[8]

Adverse Effects of *Pneumocystis* Pneumonia Prophylaxis

- **Trimethoprim-sulfamethoxazole:** Adverse reactions to trimethoprim-sulfamethoxazole occur in more than 15% of people with HIV who take it, and these reactions include rash, fever, nausea, hyperkalemia, azotemia, leukopenia, thrombocytopenia, and a transient increase in hepatic aminotransferase levels.[27] The mean onset of symptoms is 10 to 14 days after starting the medication. For most individuals who previously had a mild reaction to trimethoprim-sulfamethoxazole, such as non-severe rash, reintroducing trimethoprim-sulfamethoxazole under close supervision can be done using a suspension and gradually titrating up the dose.[27] Depending on the adverse effects experienced, supportive care should be attempted prior to discontinuation of the drug and challenge using dose titration. A reintroduction of trimethoprim-sulfamethoxazole should not be attempted in patients whose previous reactions included hepatitis, aseptic meningitis, Stevens-Johnson syndrome, or toxic epidermal necrolysis.
- **Dapsone:** Patients who are intolerant to trimethoprim-sulfamethoxazole are also at risk of developing rash when taking dapsone because the latter contains a sulfonamide moiety. In addition, dapsone can cause hemolytic anemia secondary to G6PD deficiency, methemoglobinemia, peripheral neuropathy, and sulfone syndrome (fever, lymphadenopathy, rash, hepatitis and lymphocytosis).[28]

- **Inhaled Pentamidine:** Inhaled pentamidine can induce cough and bronchospasm though generally is well tolerated.[\[29,30\]](#)
- **Atovaquone:** Atovaquone causes few serious adverse effects but the liquid formulation can be difficult for patients due to the bad taste.[\[31,32\]](#)

Toxoplasma Encephalitis

Background

Toxoplasma gondii is a protozoan parasite that can infect humans and cause encephalitis and, more rarely, retinitis, pneumonitis, and disseminated disease. Risk factors for acquiring *T. gondii* include exposure to cat feces and eating undercooked red meat or raw shellfish (Figure 4).[18] Most cases of toxoplasmosis in persons with HIV result from reactivation of latent *T. gondii* cysts as immunity wanes. In the United States, prior to the availability of effective antiretroviral therapy, the incidence of *Toxoplasma* encephalitis among people with AIDS with a CD4 count less than 100 cells/mm³ was 40 per 1,000 person-years;[33] this rate has declined to a very low level due to widespread use of antiretroviral therapy and trimethoprim-sulfamethoxazole for *Pneumocystis* pneumonia prophylaxis. All persons with HIV should have testing for IgG antibody to *T. gondii* as soon as possible after the initial diagnosis of HIV.[18] Individuals who previously had a negative IgG antibody to *Toxoplasma* and experience a CD4 count decline to less than 100 cells/mm³ should undergo repeat *Toxoplasma* IgG antibody testing if they are not already taking a medication that provides effective prophylaxis for *Toxoplasma* encephalitis.

Prevention Acquisition of *Toxoplasma Gondii* Infection

Individuals who test negative for *Toxoplasma* antibodies should receive counseling on how to prevent infection with *T. gondii*. Specifically, they should be instructed to avoid exposure to cat feces, not eat undercooked red meat or raw shellfish, and wash raw fruits and vegetables well before eating them.

Indications for Initiating Primary Prophylaxis

Prophylaxis for *Toxoplasma* encephalitis is classified as either primary prophylaxis (preventing the first episode of *Toxoplasma* encephalitis) or maintenance therapy (secondary prophylaxis) for preventing the recurrence of *Toxoplasma* encephalitis. The Adult and Adolescent OI Guidelines recommend the following as an indication for initiating primary prophylaxis for *Toxoplasma* encephalitis.[18]

- All persons with HIV and a CD4 count less than 100 cells/mm³ who are also seropositive (IgG) for *Toxoplasma* (**AII**).

Recommended Regimens for Primary Prophylaxis

The following summarizes the Adult and Adolescent OI Guidelines recommendations for *Toxoplasma* encephalitis prophylaxis (Table 2).[18] Note that all recommended regimens for *Toxoplasma* encephalitis prophylaxis are also effective for *Pneumocystis* pneumonia prophylaxis.

- **Preferred Therapy:** Trimethoprim-sulfamethoxazole is the preferred agent for *Toxoplasma* encephalitis prophylaxis in individuals with HIV.[13,34]
- **Alternative Therapy:** The following alternative regimens should be considered as alternative options for persons unable to receive trimethoprim-sulfamethoxazole for *Toxoplasma* encephalitis prophylaxis
 - **Low-Dose Trimethoprim-Sulfamethoxazole;** The recommendation for low-dose trimethoprim-sulfamethoxazole is one double-strength tablet three times a week or one single-strength tablet daily.[13,19] A trimethoprim-sulfamethoxazole desensitization protocol may be helpful for patients who develop mild adverse reactions to first-line prophylaxis with trimethoprim-sulfamethoxazole.
 - **Dapsone plus Pyrimethamine:** The use of dapsone plus pyrimethamine (with the addition of leucovorin to prevent pyrimethamine-related bone marrow toxicity) has been studied and is an effective prophylaxis for *Toxoplasma* encephalitis [13,17,35] Individuals with G6PD deficiency should not be prescribed dapsone due to the risk of hemolytic anemia.
 - **Atovaquone (with or without Pyrimethamine):** The use of atovaquone is considered the

least preferable of the recommended options. The recommendation for atovaquone is primarily based on data from two maintenance therapy (secondary prophylaxis) studies; in these studies, the use of atovaquone alone or with pyrimethamine was well tolerated and effective in preventing relapse of *Toxoplasma* encephalitis.[36,37]

Discontinuing Primary Prophylaxis

The Adult and Adolescent OI Guidelines list the following indications for discontinuation of primary *Toxoplasma* encephalitis prophylaxis.[18]

- CD4 count greater than 200 cells/mm³ for more than 3 months in response to antiretroviral therapy (**AI**)
- Can consider if the CD4 count is 100 to 200 cells/mm³ and HIV RNA levels remain below the limit of detection for at least 3 to 6 months (**BII**)

Numerous studies have consistently shown that *Toxoplasma* encephalitis prophylaxis can be safely discontinued when patients respond to antiretroviral therapy and have immune reconstitution (most studies evaluated for CD4 counts that increased above 200 cells/mm³ for more than 3 months).[38,39,40,41,42] In these studies, most patients had suppressed HIV RNA levels at the time prophylaxis was discontinued. Stopping primary prophylaxis does not require brain imaging.

Restarting Primary Prophylaxis

Primary prophylaxis should be restarted if the CD4 count decreases to less than 100 cells/mm³, regardless of the HIV RNA level.[18] For those individuals with a CD4 of 100 to 200 cells/mm³ who do not have viral suppression, primary *Toxoplasma* prophylaxis should be resumed (along with *Pneumocystis* pneumonia prophylaxis).

Disseminated *Mycobacterium avium* Complex

Background

Mycobacterium avium complex (MAC) infection is a complication of advanced HIV disease and is an independent predictor of mortality and shortened survival.[43] *Mycobacterium avium* complex represents a group of nontuberculous mycobacteria that are ubiquitous in the environment. The mode of transmission is thought to occur via inhalation, ingestion, or inoculation via the respiratory or gastrointestinal tract, but there does not seem to be any way to reliably prevent or reduce environmental exposure. Most persons with HIV who are diagnosed with disseminated MAC have a CD4 count less than 50 cells/mm³. [44,45,46] In the era prior to use of effective antiretroviral therapy, the incidence of MAC disease in patients with advanced immunosuppression was common, but rates declined dramatically after the broad use of effective antiretroviral therapy (Figure 5).[2,3] A retrospective analysis of patients with a CD4 count less than 50 cells/mm³ who were enrolled in the HIV Outpatient Study from 1996 through 2007 reported a very low overall incidence of MAC infection and no cases of disseminated MAC infection occurred in patients with an HIV RNA less than 1,000 copies/mL (Figure 6).[47] In the modern HIV era, disseminated MAC infection most often affects individuals unaware of their HIV diagnosis, or those not taking antiretroviral therapy.

Indications for Initiating Primary Prophylaxis

The Adult and Adolescent OI Guidelines recommend the following regarding primary prophylaxis against disseminated MAC.[48]

- Primary prophylaxis for MAC is not recommended in persons with HIV if antiretroviral therapy is immediately started, regardless of the individual's CD4 cell count (**AIII**). This recommendation is based on data from several observational cohort studies that found no benefit in starting MAC prophylaxis in persons with a CD4 count less than 50 cells/mm³ if they promptly started on antiretroviral therapy and achieved virologic suppression.[47,49,50]
- Persons with HIV who have a CD4 count less than 50 cells/mm³ should receive MAC prophylaxis if they are not taking fully suppressive antiretroviral therapy (**AI**). In this situation, MAC prophylaxis should start after ruling out disseminated MAC disease based on clinical assessment, which may include mycobacterial blood cultures (**AI**). The clinical assessment for disseminated MAC should include evaluation of characteristic signs and symptoms of disseminated MAC—fever, weight loss, night sweats, fatigue, diarrhea, hepatosplenomegaly, and anemia. With disseminated MAC, it often takes several weeks before a positive culture is identified. It is important to have follow-up on the culture results, since prolonged use of a macrolide antibiotic for MAC prophylaxis in a person with active MAC infection could result in the development of macrolide resistance.

Recommended Regimens for Primary Prophylaxis

The Adult and Adolescent OI Guidelines provide recommendations for preferred and alternative agents for primary prophylaxis for disseminated MAC (Table 3).[48]

- **Preferred Therapy:** If MAC prophylaxis is given, the preferred regimens are oral azithromycin (1,200 mg once weekly or 600 mg twice weekly) or oral clarithromycin (500 mg twice daily).[48] In randomized, placebo-controlled trials in persons with HIV and advanced immunosuppression, azithromycin and clarithromycin have been shown to be safe and effective in preventing disseminated MAC.[51,52] Most clinicians prefer azithromycin over clarithromycin in this situation due to better tolerance, fewer drug interactions, and more convenient dosing.
- **Alternative Therapy:** Rifabutin is moderately effective in reducing the risk of disseminated MAC.[53] Although rifabutin is considered an acceptable alternative for patients intolerant to azithromycin and clarithromycin, a systematic review has found significantly higher rates of disseminated MAC in patients treated with rifabutin alone compared to those treated with either azithromycin or

clarithromycin.[43] Note that active tuberculosis should be ruled out prior to initiating rifabutin for MAC prophylaxis.[48] The combination of rifabutin with either azithromycin or clarithromycin provides better protection against MAC infection, but is not recommended due to increased risk of adverse reactions and lack of survival benefit when compared with azithromycin or clarithromycin.[54,55]

Discontinuing Primary Prophylaxis

Primary MAC prophylaxis may be discontinued if the following criterion is met:[48]

- Effective antiretroviral therapy has been started, regardless of the CD4 cell count (**AI**).

Discontinuing MAC prophylaxis decreases pill burden and reduces the overall likelihood of developing medication-related interactions and side effects.

Restarting MAC Prophylaxis

Primary prophylaxis should be restarted in individuals who are not on fully suppressive antiretroviral therapy if their CD4 count again drops below 50 cells/mm³. [48]

Cryptococcal Meningitis

Background

Cryptococcal disease is an opportunistic fungal infection that causes significant morbidity and mortality in persons with HIV who have severe immunosuppression. The global disease burden is high, with an estimated 223,100 cases of cryptococcal meningitis occurring in 2014, mostly in sub-Saharan Africa; this estimated number of cases is significantly lower than the 957,900 cases per year estimated in 2008.[56,57] Most cryptococcal infections in persons with HIV are caused by *Cryptococcus neoformans*, though *Cryptococcus gattii* has increasingly been recognized as a causative agent of cryptococcal meningitis in certain geographic areas, particularly in the Pacific Northwest.[58] As with other opportunistic infections, the widespread use of highly active antiretroviral therapy has led to a decrease in the incidence of cryptococcal meningitis in the United States, and most cases are identified in persons with recently diagnosed HIV who have advanced immunosuppression or those with a known diagnosis of HIV, but limited access to health care.[59] In either situation, patients with cryptococcal meningitis usually have a CD4 count less than 100 cells/mm³.

Routine Cryptococcal Antigen Screening

In a retrospective analysis of 1,872 serum samples collected during 1986-2012 from patients with a CD4 count less than or equal to 100 cells/mm³ who were enrolled in the Multicenter AIDS Cohort Study or the Women's Interagency HIV Study, 2.9% (55 of 1,872) of samples tested positive for cryptococcal antigen.[60,61] Further analysis showed the rate was 4.3% among those with a CD4 count less than or equal to 50 cells/mm³ compared with 1.7% in those with a CD4 count of 51 to 100 cells/mm³. [62] Based on these data, the Adult and Adolescent OI Guidelines recommend the following regarding cryptococcal antigen screening.[63]

- Serum cryptococcal antigen (CrAg) surveillance is recommended for persons with HIV who have a CD4 count less than 100 cells/mm³ (particularly those with a CD4 count less than or equal to 50 cells/mm³); there are no recommendations regarding the recommended frequency of this surveillance.

Management of Asymptomatic Cryptococcal Antigenemia

If the CrAg screening test is positive, the individual should undergo brain imaging followed by lumbar puncture—if the lumbar puncture is considered safe based on the brain imaging. The lumbar puncture evaluation should include opening pressure and cerebrospinal fluid evaluation for cryptococcal meningitis, including cerebrospinal fluid CrAg.[63] The subsequent management of persons with asymptomatic CrAg will depend on the results of the evaluation for cryptococcal meningitis and the specific titer of the serum CrAg. The CrAg assays are now usually performed using a lateral flow assay (LFA) and a titer of 640 or greater is considered a high titer for the purposes of managing these individuals.[63]

- If the lumbar puncture result shows evidence of cryptococcal meningitis or the individual has a high titer serum CrAg (≥ 640 by LFA), then treatment should be the same as for cryptococcal meningitis, which typically is initiated with liposomal amphotericin B plus flucytosine.[63] If there is evidence of meningitis, then antiretroviral therapy should be deferred for 4 to 6 weeks.[63] For a more detailed discussion on the treatment of cryptococcal meningitis, see the lesson [Opportunistic Infections Treatment](#).
- If the lumbar puncture does not show evidence of meningitis and the individual has a low titer serum CrAg (≤ 320 by LFA), then treatment is the same as for focal pulmonary cryptococcosis, with fluconazole 400-800 mg/day. [63]

Primary Prophylaxis Not Recommended

Studies have shown that prophylactic use of fluconazole or itraconazole reduces the frequency of primary cryptococcal disease in persons with HIV who have a CD4 count below 100 cells/mm³.[\[64,65,66\]](#) Nevertheless, the Adult and Adolescent OI Guidelines do not recommend routine primary prophylaxis against cryptococcal meningitis in the absence of a positive CrAg test, due to the low risk of disease, lack of survival benefit with prophylaxis, possible drug interactions, and potential development of antifungal drug resistance **(BIII)**.[\[63\]](#) It is not feasible to avoid exposure to *C. neoformans*, which is found in soil throughout the United States, so the chief means of prevention is the use of antiretroviral therapy to optimize immune function.

Cytomegalovirus

Background

Cytomegalovirus (CMV) is a double-stranded DNA herpes virus that can cause invasive disease in persons with HIV, including CMV retinitis, colitis, esophagitis, and neurologic disease.[67,68,69,70] Most cases of CMV end-organ disease in persons with HIV result from reactivation of latent infection in persons who are CMV-seropositive and have a CD4 count less than 50 cells/mm³. [71,72] In persons with HIV, retinitis is the most common manifestation of CMV-related end-organ disease.[70,71] Among men with HIV infection who have sex with men, CMV antibody positivity rates are greater than 90%. Additional risk factors for the development of clinical CMV disease include previous opportunistic infections, a high HIV RNA level (greater than 100,000 copies/mL) and a high level of CMV viremia.[72] The incidence of CMV end-organ disease, such as CMV retinitis, is now low and it has declined by more than 95% following the widespread availability of effective antiretroviral therapy.[3,73,74,75]

Primary Prophylaxis and Preemptive Therapy Not Recommended

The most important way to prevent CMV end-organ disease in persons with HIV is to use antiretroviral therapy to restore and optimize immune system function in those with severe immunosuppression.[72] In the ACTG A5030 trial, preemptive valganciclovir therapy was evaluated for individuals with a CD4 count less than 100 cells/mm³ (on stable antiretroviral therapy) and CMV viremia, but this strategy of preemptive therapy was not protective.[75] Thus, in the modern antiretroviral therapy era, the Adult and Adolescent OI Guidelines do not recommend prophylactic or preemptive therapy as a strategy to prevent CMV disease.[72]

Patient Education and Screening Examinations

Recognizing early signs of CMV-related disease and implementing appropriate therapy will diminish the severity of the disease. Individuals with HIV and advanced immunosuppression should be educated about the warning signs of active CMV retinitis, including floaters, flashing lights, or any decrease in vision. In addition, since some individuals may be asymptomatic with early CMV retinitis, most experts recommend a formal ophthalmologic examination for any person with HIV with a CD4 count less than 50 cells/mm³ every 3 to 4 months (and some recommend performing this screening when the CD4 count is less than 100 cells/mm³). [72] The screening ophthalmologic examination is particularly important for patients anticipating starting antiretroviral therapy, since patients with untreated or unrecognized CMV retinitis are at significant risk of developing CMV immune reconstitution inflammatory syndrome following initiation of antiretroviral therapy.[72]

Histoplasmosis

Background

Histoplasmosis is a fungal infection caused by *Histoplasma capsulatum*, which is the most common endemic mycosis in the United States.[76,77] The central and south-central regions of the United States, especially along the Ohio and Mississippi River valleys, are considered hyperendemic, as are many regions in Mexico and South America (Figure 7).[76,78] The organism *H. capsulatum* grows in soil enriched with nitrogen, as occurs with soil that has abundant bird or bat guano. *Histoplasma* infections are acquired through inhalation of microconidia in the mycelial phase; the microconidia convert to the yeast forms once in the lungs (Figure 8). Most cases of histoplasmosis in persons with HIV result from reactivation of latent *Histoplasma* infection after the CD4 count has declined to less than 150 cells/mm³. [79] The incidence of histoplasmosis declined markedly after the widespread use of effective antiretroviral therapy. In some instances, however, immune reconstitution in response to antiretroviral therapy may unmask latent, undiagnosed *Histoplasma* infection.[80]

Preventing Exposure

The Adult and Adolescent OI Guidelines recommend that persons with HIV who have a CD4 count less than 150 cells/mm³ and who live in or visit a histoplasmosis endemic area should avoid the following activities known to increase the risk of exposure to *H. capsulatum*: working with surface soil, cleaning chicken coops that are contaminated with droppings, disturbing areas that are contaminated with bird or bat droppings, cleaning or remodeling old buildings, or exploring caves (BIII).[81]

Routine *Histoplasma* Antigen Screening Not Recommended

There are no recommendations for performing routine screening of asymptomatic persons with HIV using the urinary *Histoplasma* antigen.

Indications for Initiating Primary Prophylaxis

In a National Institute of Allergy and Infectious Diseases Mycoses Study Group, placebo-controlled, double-blind study, itraconazole 200 mg daily was evaluated as prophylaxis for fungal infections among individuals with advanced HIV; use of itraconazole was associated with a significant delayed time to onset of histoplasmosis, but no demonstrable survival benefit.[64] The Adult and Adolescent OI Guidelines note that some experts recommend the following as an indication for histoplasmosis primary prophylaxis.[81]

- CD4 count less than 150 cells/mm³ and the individual is at high risk because of occupational exposure or living in a community with a hyperendemic rate of histoplasmosis (greater than 10 cases/100 patient-years) (BI)

Recommended Regimens for Primary Prophylaxis

- **Preferred Therapy:** If prophylaxis for histoplasmosis is used, oral itraconazole 200 mg once daily is recommended (BI)
- **Alternative Therapy:** There are no alternative therapies recommended for prophylaxis of histoplasmosis.

Discontinuing Primary Prophylaxis

Primary prophylaxis for *Histoplasma* can be stopped in persons on effective antiretroviral therapy once they have an undetectable HIV RNA level and their CD4 count is 150 cells/mm³ or greater for at least 6 months

(BIII). Primary prophylaxis should be restarted if the CD4 count drops below 150 cells/mm³ **(BIII)**.

Coccidioidomycosis

Background

Coccidioidomycosis is caused by soil-dwelling fungi, either *Coccidioides immitis*, or *C. posadasii*. Coccidioidomycosis encompasses a wide spectrum of clinical disease among individuals with HIV. The risk of developing symptomatic coccidioidomycosis is significantly increased in persons with HIV who have a CD4 count less than 250 cells/mm³ and live (or have lived) in a region endemic for coccidioidomycosis.[82] The endemic areas for coccidioidomycosis include the Southwest desert region of the United States, as well as parts of Central and South America. The regions in the United States identified as highly endemic are the lower San Joaquin Valley in California, most of Arizona, the southern regions of Utah, Nevada, and New Mexico, and western Texas (Figure 9). Infection results from inhalation of the *C. immitis* arthroconidia, which then undergo morphologic changes inside the human host to endospores that can disseminate and cause disease in almost any organ (Figure 10). Only a low inoculum of arthroconidia are needed to establish infection.[83] Persons who live in an endemic area should receive counseling regarding exposure to *C. immitis*, such as attempting to avoid dust storms or significant contact with dust, particularly with construction or excavation sites. The incidence of coccidioidomycosis in persons with HIV has decreased in the era of potent antiretroviral therapy.[84]

Preventing Exposure

Persons with HIV should be aware of the geographic regions that are endemic for coccidioidomycosis. They should receive counseling regarding avoiding exposure to *C. immitis* and *C. posadasii*, including avoiding significant contact with dust, dust storms, or any area with recently disturbed soil, such as an excavation site (BIII).[82]

Primary Prophylaxis Not Indicated

The Adult and Adolescent OI Guidelines recommend against the routine use of primary antifungal prophylaxis for coccidioidomycosis (i.e., providing prophylaxis to individuals with HIV who have negative serologic testing for coccidioidomycosis), even for persons with a low CD4 cell count who live in endemic regions (AIII).[82]

Serologic Screening and Monitoring and Preventing Disease

For persons with HIV who have negative serologic tests for coccidioidomycosis, guidelines suggest obtaining yearly or twice-yearly *Coccidioides* serologic testing if they are living in an area endemic for coccidioidomycosis.[82] Serologic testing is also recommended for persons who have previously lived (or extensively traveled) to a region endemic for coccidioidomycosis.[82] Routine coccidioidal serologic screening is not recommended for asymptomatic individuals who have not lived in or traveled to endemic areas.[82] Individuals who undergo serologic testing and have a newly positive test (either IgM or IgG) should undergo further clinical evaluation for active coccidioidomycosis and if active disease is detected, then appropriate therapy should be administered.[82]

Initiation of Primary Prophylaxis

The following three criteria should be met for initiating coccidioidomycosis primary prophylaxis:

- New positive IgM and/or IgG test for *Coccidioides*, and
- No sign of active coccidioidomycosis, and
- CD4 count less than 250 cells/mm³

Note: The Adult and Adolescent OI Guidelines do not clarify the approach for a person who tests positive for coccidioidomycosis, but has not had previous serologic testing (making it unclear whether the results truly

represent a new positive test).[82]

Preferred Therapy for Primary Prophylaxis

- Fluconazole 400 mg once daily is the preferred agent to prevent active coccidioidomycosis disease (**AIII**).

Discontinuing Fluconazole

If fluconazole is administered to prevent active coccidioidomycosis disease, it should be continued until the CD4 count is 250 cells/mm³ or higher and HIV RNA levels are consistently suppressed (**BIII**).[82]

Summary Points

- The overall incidence of opportunistic infections has markedly declined with the widespread use of highly active antiretroviral therapy and the routine use of chemoprophylaxis against common infections.
- Primary prophylaxis (to prevent the first episode of an opportunistic infection) based on established CD4 count thresholds is indicated for *Pneumocystis pneumonia* and *Toxoplasma encephalitis*.
- Prophylaxis for disseminated *Mycobacterium avium* complex is not recommended in persons initiating suppressive antiretroviral therapy, regardless of CD4 cell count.

- Primary prophylaxis is not indicated for cryptococcal meningitis, cytomegalovirus infection, or coccidioidomycosis.
- Primary prophylaxis for histoplasmosis is recommended by some experts, but only for persons who have a CD4 count less than 150 cells/mm³ and are at risk due to occupational exposure or residence in a region with a hyperendemic rate of histoplasmosis (greater than 10 cases/100 patient-years).
- Primary prophylaxis should be discontinued after immune restoration has occurred with antiretroviral therapy in order to reduce pill burden, cost, the risk of drug interactions and toxicity, and the possibility of engendering drug resistance.

Citations

1. Brooks JT, Kaplan JE, Holmes KK, Benson C, Pau A, Masur H. HIV-associated opportunistic infections--going, going, but not gone: the continued need for prevention and treatment guidelines. *Clin Infect Dis*. 2009;48:609-11.
[PubMed Abstract] -
2. Buchacz K, Baker RK, Palella FJ Jr, et al. AIDS-defining opportunistic illnesses in US patients, 1994-2007: a cohort study. *AIDS*. 2010;24:1549-59.
[PubMed Abstract] -
3. Buchacz K, Lau B, Jing Y, et al. Incidence of AIDS-Defining Opportunistic Infections in a Multicohort Analysis of HIV-infected Persons in the United States and Canada, 2000-2010. *J Infect Dis*. 2016;214:862-72.
[PubMed Abstract] -
4. 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.
[HIV.gov] -
5. Lundberg BE, Davidson AJ, Burman WJ. Epidemiology of *Pneumocystis carinii* pneumonia in an era of effective prophylaxis: the relative contribution of non-adherence and drug failure. *AIDS*. 2000;14:2559-66.
[PubMed Abstract] -
6. Kaplan JE, Hanson DL, Navin TR, Jones JL. Risk factors for primary *Pneumocystis carinii* pneumonia in human immunodeficiency virus-infected adolescents and adults in the United States: reassessment of indications for chemoprophylaxis. *J Infect Dis*. 1998;178:1126-32.
[PubMed Abstract] -
7. Phair J, Munoz A, Detels R, Kaslow R, Rinaldo C, Saah A. The risk of *Pneumocystis carinii* pneumonia among men infected with human immunodeficiency virus type 1. Multicenter AIDS Cohort Study Group. *N Engl J Med*. 1990;322:161-5.
[PubMed Abstract] -
8. 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. *Pneumocystis* Pneumonia. Updated: March 28, 2019.
[HIV.gov] -
9. Heald A, Flepp M, Chave JP, et al. Treatment for cerebral toxoplasmosis protects against *Pneumocystis carinii* pneumonia in patients with AIDS. The Swiss HIV Cohort Study. *Ann Intern Med*. 1991;115:760-3.
[PubMed Abstract] -
10. Schneider MM, Hoepelman AI, Eeftinck Schattenkerk JK, et al. A controlled trial of aerosolized pentamidine or trimethoprim sulfamethoxazole as primary prophylaxis against *Pneumocystis carinii* pneumonia in patients with human immunodeficiency virus infection. The Dutch AIDS Treatment Group. *N Engl J Med*. 1992;327:1836-41.

[\[PubMed Abstract\]](#) -

11. Bozzette SA, Finkelstein DM, Spector SA, et al. A randomized trial of three antipneumocystis agents in patients with advanced human immunodeficiency virus infection. NIAID AIDS Clinical Trials Group. *N Engl J Med.* 1995;332:693-9.
[\[PubMed Abstract\]](#) -
12. Schneider MM, Nielsen TL, Nelsing S, et al. Efficacy and toxicity of two doses of trimethoprim-sulfamethoxazole as primary prophylaxis against *Pneumocystis carinii* pneumonia in patients with human immunodeficiency virus. Dutch AIDS Treatment Group. *J Infect Dis.* 1995;171:1632-6.
[\[PubMed Abstract\]](#) -
13. Podzamczar D, Salazar A, Jimenez J, et al. Intermittent trimethoprim-sulfamethoxazole compared with dapsone-pyrimethamine for the simultaneous primary prophylaxis of *Pneumocystis pneumonia* and toxoplasmosis in patients infected with HIV. *Ann Intern Med.* 1995;122:755-61.
[\[PubMed Abstract\]](#) -
14. El-Sadr WM, Luskin-Hawk R, Yurik TM, et al. A randomized trial of daily and thrice-weekly trimethoprim-sulfamethoxazole for the prevention of *Pneumocystis carinii* pneumonia in human immunodeficiency virus-infected persons. Terry Bein Community Programs for Clinical Research on AIDS (CPCRA) *Clin Infect Dis.* 1999;29:775-83.
[\[PubMed Abstract\]](#) -
15. El-Sadr WM, Murphy RL, Yurik TM, et al. Atovaquone compared with dapsone for the prevention of *Pneumocystis carinii* pneumonia in patients with HIV infection who cannot tolerate trimethoprim, sulfonamides, or both. Community Program for Clinical Research on AIDS and the AIDS Clinical Trials Group. *N Engl J Med.* 1998;339:1889-95.
[\[PubMed Abstract\]](#) -
16. Chan C, Montaner J, Lefebvre EA, et al. Atovaquone suspension compared with aerosolized pentamidine for prevention of *Pneumocystis carinii* pneumonia in human immunodeficiency virus-infected subjects intolerant of trimethoprim or sulfonamides. *J Infect Dis.* 1999;180:369-76.
[\[PubMed Abstract\]](#) -
17. Girard PM, Landman R, Gaudebout C, et al. Dapsone-pyrimethamine compared with aerosolized pentamidine as primary prophylaxis against *Pneumocystis carinii* pneumonia and toxoplasmosis in HIV infection. The PRIO Study Group. *N Engl J Med.* 1993;328:1514-20.
[\[PubMed Abstract\]](#) -
18. 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. *Toxoplasma gondii* encephalitis. Updated: July 25, 2017.
[\[HIV.gov\]](#) -
19. Carr A, Tindall B, Brew BJ, Marriott DJ, Harkness JL, Penny R, Cooper DA. Low-dose trimethoprim-sulfamethoxazole prophylaxis for toxoplasmic encephalitis in patients with AIDS. *Ann Intern Med.* 1992;117:106-11.
[\[PubMed Abstract\]](#) -
20. Gallant J. Get Rich Quick With Old Generic Drugs! The Pyrimethamine Pricing Scandal. *Open Forum Infect Dis.* 2015;2:ofv177.
[\[PubMed Abstract\]](#) -

21. Green H, Hay P, Dunn DT, McCormack S. A prospective multicentre study of discontinuing prophylaxis for opportunistic infections after effective antiretroviral therapy. *HIV Med.* 2004;5:278-83. [\[PubMed Abstract\]](#) -
22. Lopez Bernaldo de Quiros JC, Miro JM, Peña JM, et al. A randomized trial of the discontinuation of primary and secondary prophylaxis against *Pneumocystis carinii* pneumonia after highly active antiretroviral therapy in patients with HIV infection. Grupo de Estudio del SIDA 04/98. *N Engl J Med.* 2001;344:159-67. [\[PubMed Abstract\]](#) -
23. Furrer H, Opravil M, Rossi M, et al. Discontinuation of primary prophylaxis in HIV-infected patients at high risk of *Pneumocystis carinii* pneumonia: prospective multicentre study. *AIDS.* 2001;15:501-7. [\[PubMed Abstract\]](#) -
24. Costiniuk CT, Fergusson DA, Doucette S, Angel JB. Discontinuation of *Pneumocystis jirovecii* pneumonia prophylaxis with CD4 count <200 cells/ μ L and virologic suppression: a systematic review. *PLoS One.* 2011;6: e28570. [\[PubMed Abstract\]](#) -
25. D'Egidio GE, Kravcik S, Cooper CL, Cameron DW, Fergusson DA, Angel JB. *Pneumocystis jirovecii* pneumonia prophylaxis is not required with a CD4+ T-cell count [\[PubMed Abstract\]](#) -
26. Opportunistic Infections Project Team of the Collaboration of Observational HIV Epidemiological Research in Europe (COHERE), Mocroft A, Reiss P, et al. Is it safe to discontinue primary *Pneumocystis jirovecii* pneumonia prophylaxis in patients with virologically suppressed HIV infection and a CD4 cell count Para MF, Finkelstein D, Becker S, Dohn M, Walawander A, Black JR. Reduced toxicity with gradual initiation of trimethoprim-sulfamethoxazole as primary prophylaxis for Hughes WT. Use of dapsone in the prevention and treatment of *Pneumocystis carinii* pneumonia: a review. *Clin Infect Dis.* 1998 Jul;27:191-204. Acute pulmonary effects of aerosolized pentamidine. A randomized controlled study. Toronto Aerosolized Pentamidine Study (TAPS) Group. *Chest.* 1990;98:907-10. Obaji J, Lee-Pack LR, Gutierrez C, Chan CK. The pulmonary effects of long-term exposure to aerosol pentamidine: a 5-year surveillance study in HIV-infected patients. *Chest.* 2003;123:1983-7. El-Sadr WM, Burman WJ, Grant LB, et al. Discontinuation of prophylaxis for Rosenberg DM, McCarthy W, Slavinsky J, et al. Atovaquone suspension for treatment of *Pneumocystis carinii* pneumonia in HIV-infected patients. *AIDS.* 2001;15:211-4. Jones JL, Hanson DL, Chu SY, Ciesielski CA, Kaplan JE, Ward JW, Navin TR. Toxoplasmic encephalitis in HIV-infected persons: risk factors and trends. The Adult/Adolescent Spectrum of Disease Group. *AIDS.* 1996;10:1393-9. Bucher HC, Griffith L, Guyatt GH, Opravil M. Meta-analysis of prophylactic treatments against *Pneumocystis carinii* pneumonia and toxoplasma encephalitis in HIV-infected patients. *J Acquir Immune Defic Syndr Hum Retrovirol.* 1997;15:104-14. Opravil M, Hirschel B, Lazzarin A, et al. Once-weekly administration of dapsone/pyrimethamine vs. aerosolized pentamidine as combined prophylaxis for Chirgwin K, Hafner R, Leport C, et al. Randomized phase II trial of atovaquone with pyrimethamine or sulfadiazine for treatment of toxoplasmic encephalitis in patients with acquired immunodeficiency syndrome: ACTG 237/ANRS 039 Study. *AIDS Clinical Trials Group 237/Agence Nationale de Recherche sur le SIDA, Essai 039. Clin Infect Dis.* 2002;34:1243-50. Katlama C, Mouthon B, Gourdon D, Lapierre D, Rousseau F. Atovaquone as long-term suppressive therapy for toxoplasmic encephalitis in patients with AIDS and multiple drug intolerance. Atovaquone Expanded Access Group. *AIDS.* 1996;10:1107-12. Dworkin MS, Hanson DL, Kaplan JE, Jones JL, Ward JW. Risk for preventable opportunistic infections in persons with AIDS after antiretroviral therapy increases CD4+ T lymphocyte counts above prophylaxis thresholds. *J Infect Dis.* 2000;182:611-5. Furrer H, Opravil M, Bernasconi E, Telenti A, Egger M. Stopping primary prophylaxis in HIV-1-infected patients at high risk of toxoplasma encephalitis. Swiss HIV Cohort Study. *Lancet.* 2000;355:2217-8. Kirk O, Lundgren JD, Pedersen C, Nielsen H, Gerstoft J. Can chemoprophylaxis against opportunistic infections be discontinued after an increase in CD4 cells

Health, and the HIV Medicine Association of the Infectious Diseases Society of America. Cytomegalovirus disease. Updated: July 1, 2021. Schwarcz L, Chen MJ, Vittinghoff E, Hsu L, Schwarcz S. Declining incidence of AIDS-defining opportunistic illnesses: results from 16 years of population-based AIDS surveillance. *AIDS*. 2013;27:597-605. Jabs DA, Van Natta ML, Holbrook JT, Kempen JH, Meinert CL, Davis MD. Longitudinal study of the ocular complications of AIDS: 1. Ocular diagnoses at enrollment. *Ophthalmology*. 2007;114:780-6. Wohl DA, Kendall MA, Andersen J, et al. Low rate of CMV end-organ disease in HIV-infected patients despite low CD4+ cell counts and CMV viremia: results of ACTG protocol A5030. *HIV Clin Trials*. 2009;10:143-52. Wheat LJ, Azar MM, Bahr NC, Spec A, Relich RF, Hage C. Histoplasmosis. *Infect Dis Clin North Am*. 2016;30:207-27. Chu JH, Feudtner C, Heydon K, Walsh TJ, Zaoutis TE. Hospitalizations for endemic mycoses: a population-based national study. *Clin Infect Dis*. 2006;42:822-5. Wheat LJ, Freifeld AG, Kleiman MB, Baddley JW, McKinsey DS, Loyd JE, Kauffman CA; Infectious Diseases Society of America. Clinical practice guidelines for the management of patients with histoplasmosis: 2007 update by the Infectious Diseases Society of America. *Clin Infect Dis*. 2007;45:807-25. McKinsey DS, Spiegel RA, Hutwagner L, et al. Prospective study of histoplasmosis in patients infected with human immunodeficiency virus: incidence, risk factors and pathophysiology. *Clin Infect Dis*. 1997;24:1195-203. Nacher M, Sarazin F, El Guedj M, et al. Increased incidence of disseminated histoplasmosis following highly active antiretroviral therapy initiation. *J Acquir Immune Defic Syndr*. 2006;41:468-70. 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. Histoplasmosis. Last updated: September 13, 2019. 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. Coccidioidomycosis. Updated: February 17, 2021. Stockamp NW, Thompson GR 3rd. Coccidioidomycosis. *Infect Dis Clin North Am*. 2016;30:229-46. Masannat FY, Ampel NM. Coccidioidomycosis in patients with HIV-1 infection in the era of potent antiretroviral therapy. *Clin Infect Dis*. 2010;50:1-7.

References

- Au Eong KG, Beatty S, Charles SJ. Cytomegalovirus retinitis in patients with acquired immune deficiency syndrome. *Postgrad Med J*. 1999;75:585-90. [\[PubMed Abstract\]](#) -
- Brooks JT, Song R, Hanson DL, Wolfe M, Swerdlow DL; Adult and Adolescent Spectrum of Disease Working Group. Discontinuation of primary prophylaxis against *Mycobacterium avium complex* infection in HIV-infected persons receiving antiretroviral therapy: observations from a large national cohort in the United States, 1992-2002. *Clin Infect Dis*. 2005;41:549-53. [\[PubMed Abstract\]](#) -
- Centers for Disease Control and Prevention (CDC). Emergence of *Cryptococcus gattii*-- Pacific Northwest, 2004-2010. *MMWR Morb Mortal Wkly Rep*. 2010;59:865-8. [\[PubMed Abstract\]](#) -
- Currier JS, Williams PL, Koletar SL, et al. Discontinuation of *Mycobacterium avium complex* prophylaxis in patients with antiretroviral therapy-induced increases in CD4+ cell count. A randomized, double-blind, placebo-controlled trial. AIDS Clinical Trials Group 362 Study Team. *Ann Intern Med*. 2000;133:493-503. [\[PubMed Abstract\]](#) -
- Daley CL. *Mycobacterium avium Complex Disease*. *Microbiol Spectr*. 2017 Apr;5:. [\[PubMed Abstract\]](#) -

- Furrer H, Telenti A, Rossi M, Ledergerber B. Discontinuing or withholding primary prophylaxis against *Mycobacterium avium* in patients on successful antiretroviral combination therapy. The Swiss HIV Cohort Study. *AIDS*. 2000;14:1409-12.
[PubMed Abstract] -
- Gardner EM, McLees MP, Steiner JF, Del Rio C, Burman WJ. The spectrum of engagement in HIV care and its relevance to test-and-treat strategies for prevention of HIV infection. *Clin Infect Dis*. 2011;52:793-800.
[PubMed Abstract] -
- Gingo MR, Balasubramani GK, Kingsley L, et al. The impact of HAART on the respiratory complications of HIV infection: longitudinal trends in the MACS and WIHS cohorts. *PLoS One*. 2013;8:e58812.
[PubMed Abstract] -
- Hajjeh RA. Disseminated histoplasmosis in persons infected with human immunodeficiency virus. *Clin Infect Dis*. 1995 Aug;21 Suppl 1:S108-10.
[PubMed Abstract] -
- Havlik JA Jr, Horsburgh CR Jr, Metchock B, Williams PP, Fann SA, Thompson SE 3rd. Disseminated *Mycobacterium avium* complex infection: clinical identification and epidemiologic trends. *J Infect Dis*. 1992;165:577-80.
[PubMed Abstract] -
- Kaplan JE, Vallabhaneni S, Smith RM, Chideya-Chihota S, Chehab J, Park B. Cryptococcal antigen screening and early antifungal treatment to prevent cryptococcal meningitis: a review of the literature. *J Acquir Immune Defic Syndr*. 2015;68 Suppl 3:S331-9.
[PubMed Abstract] -
- Kovacs JA, Gill VJ, Meshnick S, Masur H. New insights into transmission, diagnosis, and drug treatment of *Pneumocystis carinii* pneumonia. *JAMA*. 2001;286:2450-60.
[PubMed Abstract] -
- Miro JM, Lopez JC, Podzamczar D, et al. Discontinuation of primary and secondary *Toxoplasma gondii* prophylaxis is safe in HIV-infected patients after immunological restoration with highly active antiretroviral therapy: results of an open, randomized, multicenter clinical trial. *Clin Infect Dis*. 2006;43:79-89.
[PubMed Abstract] -
- Mocroft A, Reiss P, Kirk O, et al. Is it safe to discontinue primary *Pneumocystis jirovecii* pneumonia prophylaxis in patients with virologically suppressed HIV infection and a CD4 cell count Njei B, Kongnyuy EJ, Kumar S, Okwen MP, Sankar MJ, Mbuagbaw L. Optimal timing for antiretroviral therapy initiation in patients with HIV infection and concurrent cryptococcal meningitis. *Cochrane Database Syst Rev*. 2013;2:CD009012. Saag MS, Cloud GA, Graybill JR, et al. A comparison of itraconazole versus fluconazole as maintenance therapy for AIDS-associated cryptococcal meningitis. National Institute of Allergy and Infectious Diseases Mycoses Study Group. *Clin Infect Dis*. 1999;28:291-6. Spector SA, McKinley GF, Lalezari JP, et al. Oral ganciclovir for the prevention of cytomegalovirus disease in persons with AIDS. Roche Cooperative Oral Ganciclovir Study Group. *N Engl J Med*. 1996;334:1491-7.

Figures

Figure 1 Incidence of First AIDS-Defining Opportunistic Infection, HIV Outpatient Study, 1994-2007

Source: Brooks JT, Kaplan JE, Holmes KK, Benson C, Pau A, Masur H. HIV-associated opportunistic infections--going, going, but not gone: the continued need for prevention and treatment guidelines. Clin Infect Dis. 2009;48:609-11.

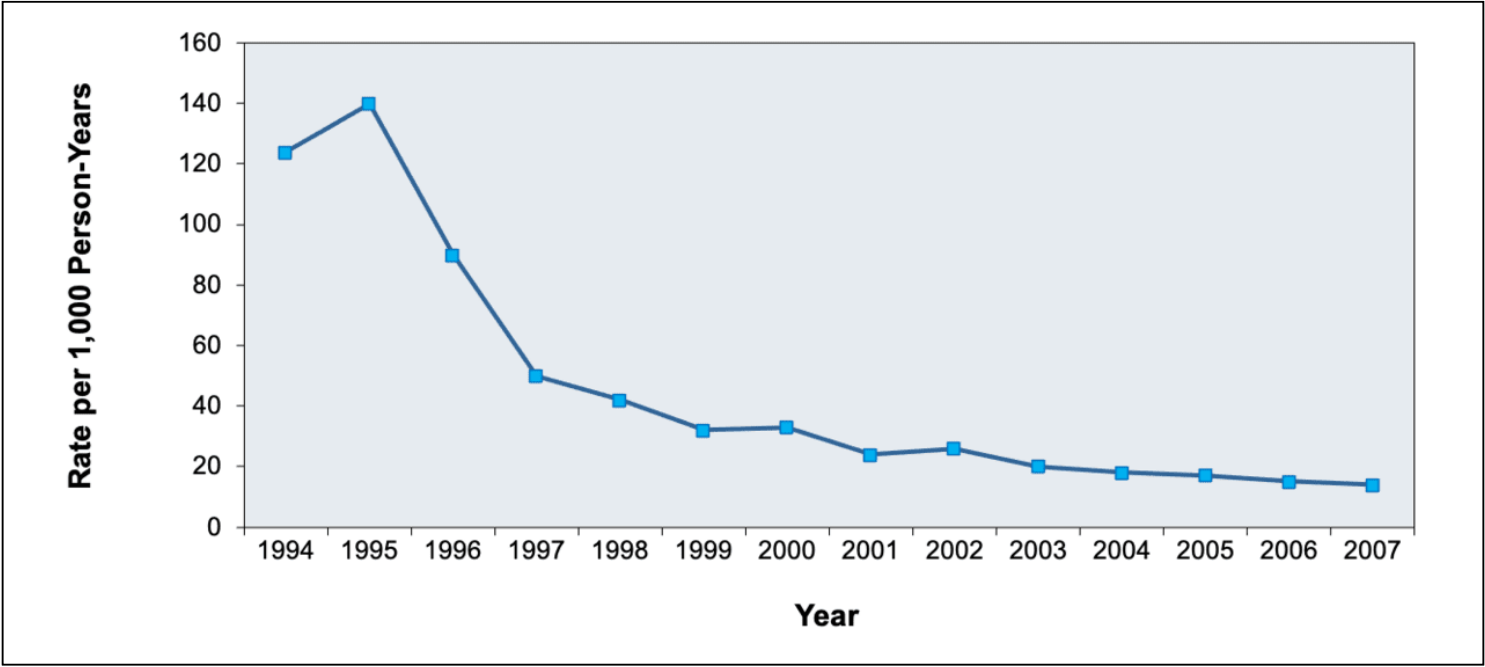


Figure 2 AIDS-Defining Opportunistic Illnesses in United States, HIV Outpatient Cohort Study, 1994-2007

Source: Buchacz K, Baker RK, Palella FJ Jr, et al. AIDS-defining opportunistic illnesses in US patients, 1994-2007: a cohort study. AIDS. 2010;24:1549-59.

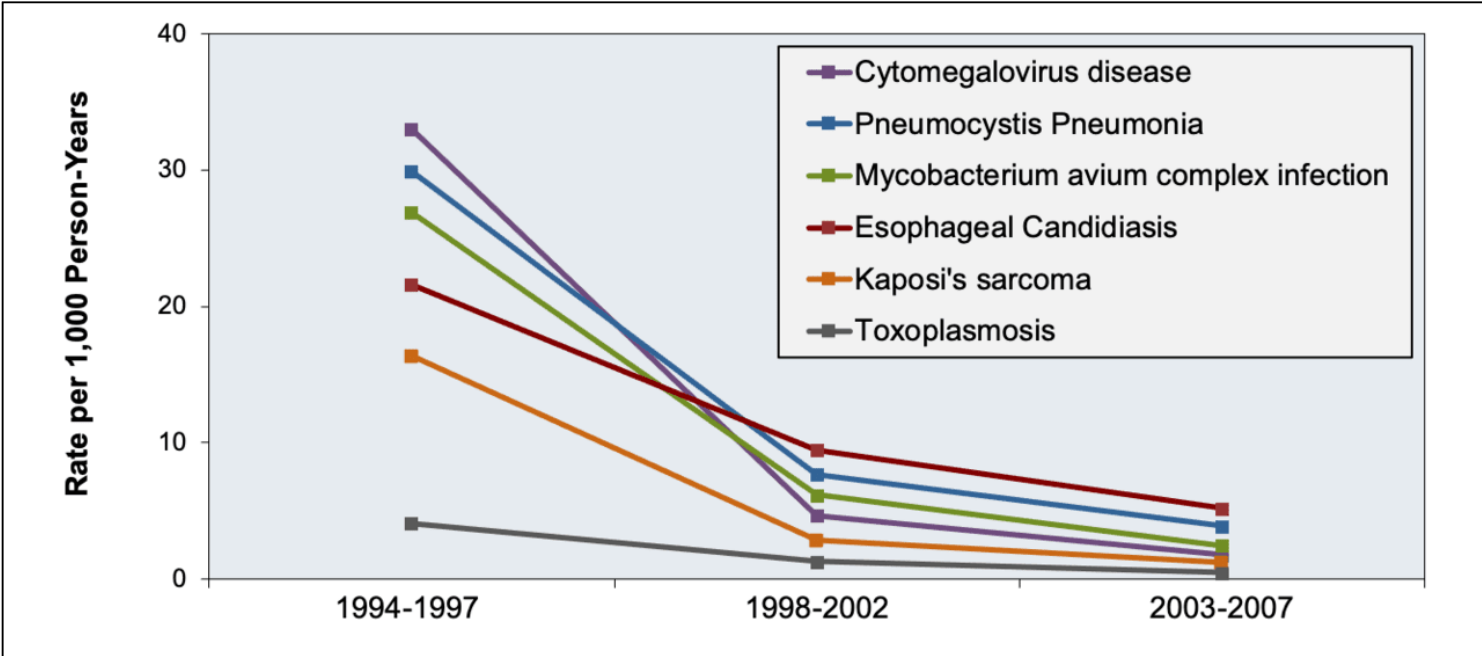


Figure 3 AIDS-Defining Opportunistic Illnesses in United States and Canada, NA-ACCORD, 2000-2010

This graph shows AIDS-Defining Opportunistic Illnesses among participants in 16 cohorts in the North American AIDS Cohort Collaboration on Research and Design (NA-ACCORD) during 2000-2010 in the United States and Canada. These data show opportunistic infections occurred at a relatively low rate and declined during the study time period.

Source: Buchacz K, Lau B, Jing Y, et al. Incidence of AIDS-Defining Opportunistic Infections in a Multicohort Analysis of HIV-infected Persons in the United States and Canada, 2000-2010. *J Infect Dis.* 2016;214:862-72.

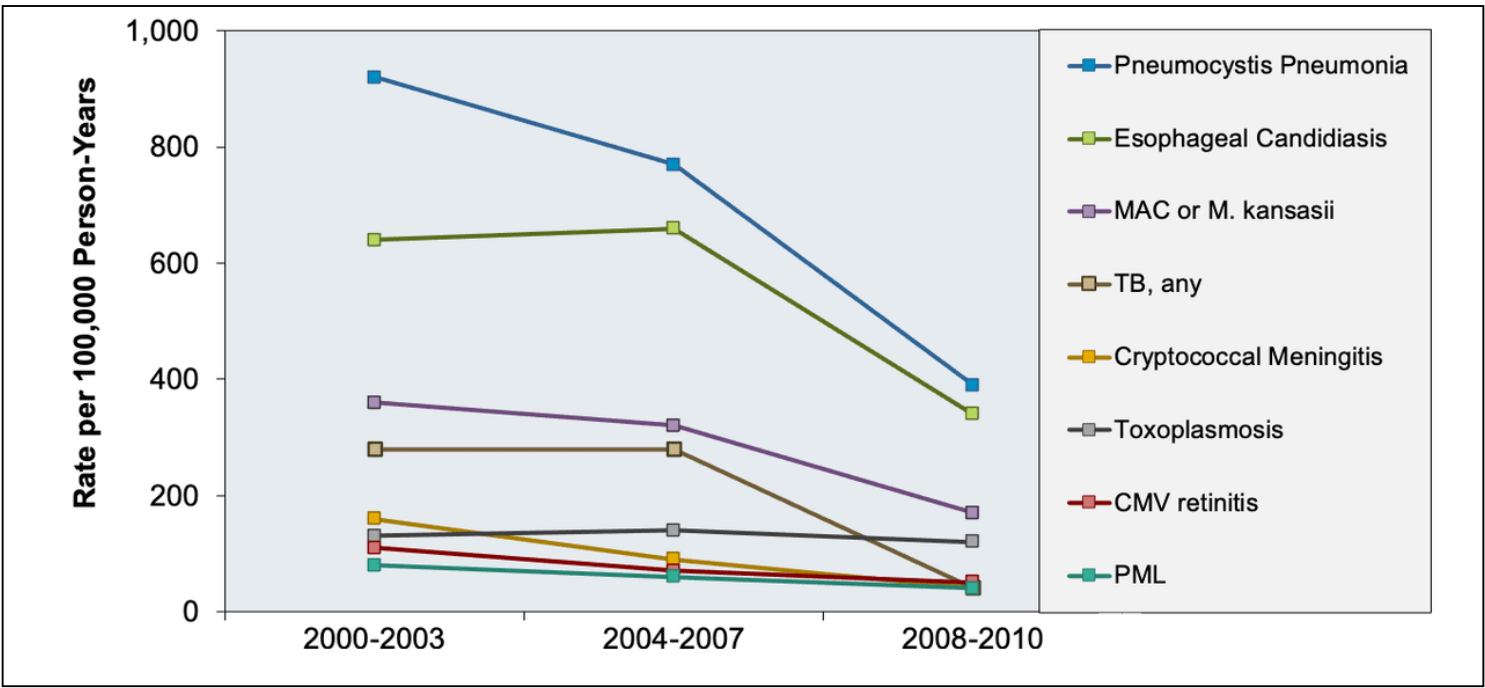


Figure 4 *Toxoplasma gondii* Life Cycle and Human Infection

Humans predominantly acquire *T. gondii* infection by either having contact with infected cat feces contaminated with *T. gondii* oocysts or by ingestion of *T. gondii* tissue cysts in undercooked red meat or shellfish. Cats can also become infected by consuming tissue cysts in undercooked or raw red meat. After humans ingest *T. gondii*, the infection can spread throughout the body. Among persons with HIV infection, latent *T. gondii* infection in the brain can reactivate with severe immunosuppression and cause Toxoplasma encephalitis.

Illustration by David Ehlert, Cognition Studio, Inc.

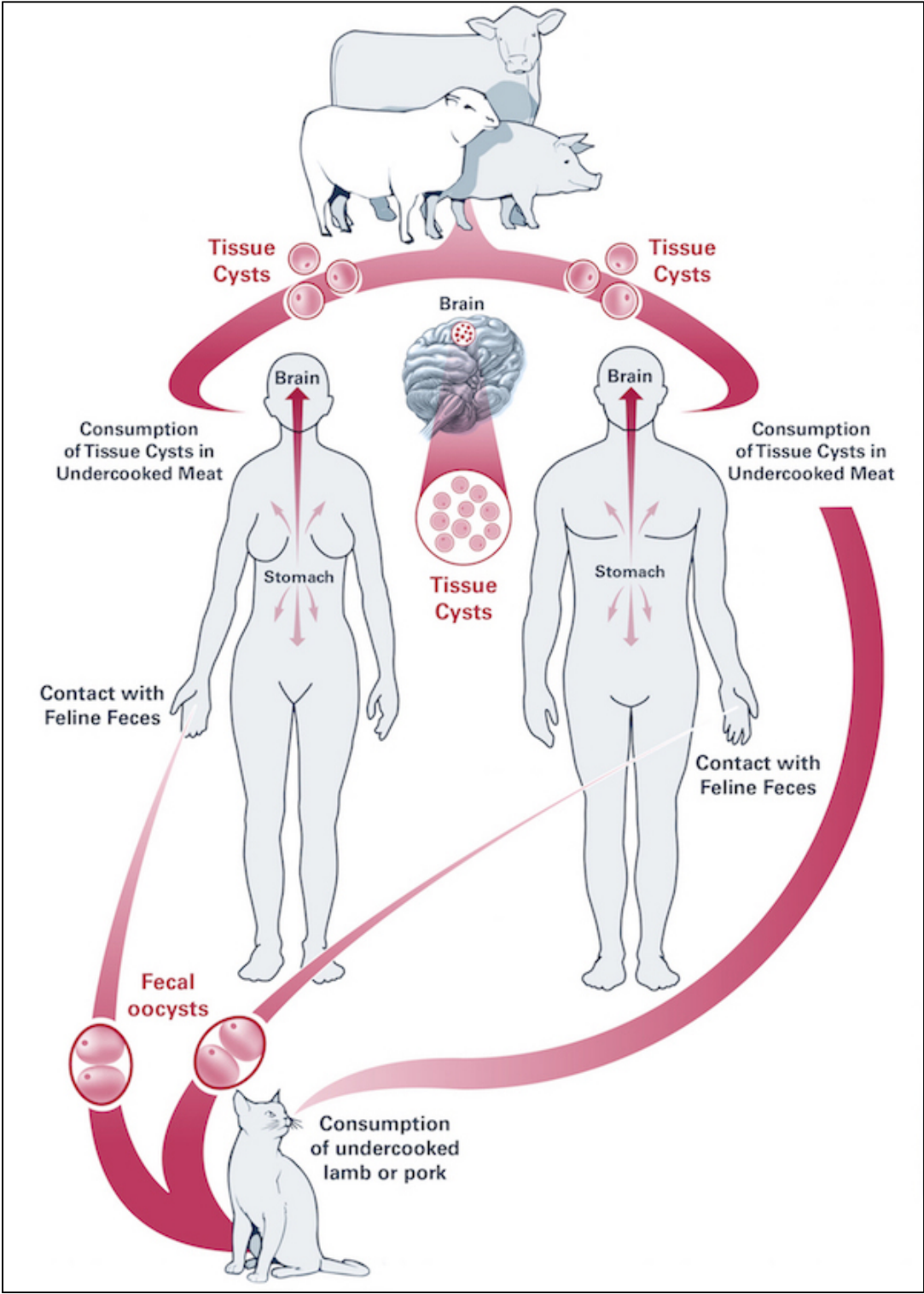


Figure 5 Incidence of Disseminated *Mycobacterium avium* Complex Infection, 1994-2007

Source: Buchacz K, Baker RK, Palella FJ Jr, et al. AIDS-defining opportunistic illnesses in US patients, 1994-2007: a cohort study. *AIDS*. 2010;24:1549-59.

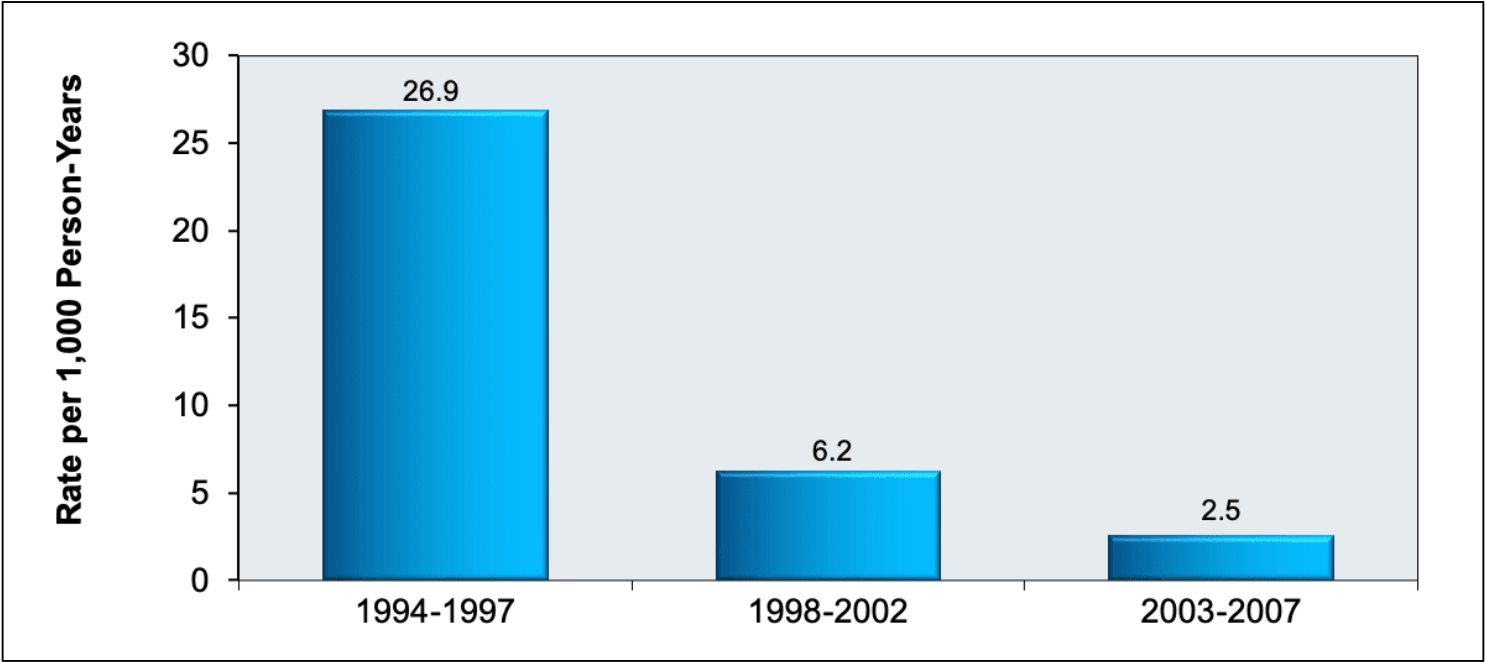


Figure 6 *Mycobacterium avium* Complex Infection Rate in the HIV Outpatient Study, 1996-2007

In the HIV Outpatient Study (HOPS) investigators performed a retrospective analysis to determine the MAC incidence rate in 369 individuals with HIV infection, a CD4 count less than 50 cells/mm³, and no prior history of MAC infection

Source: Yangco BG, Buchacz K, Baker R, Palella FJ, Armon C, Brooks JT. Is primary *Mycobacterium avium* complex prophylaxis necessary in patients with CD4

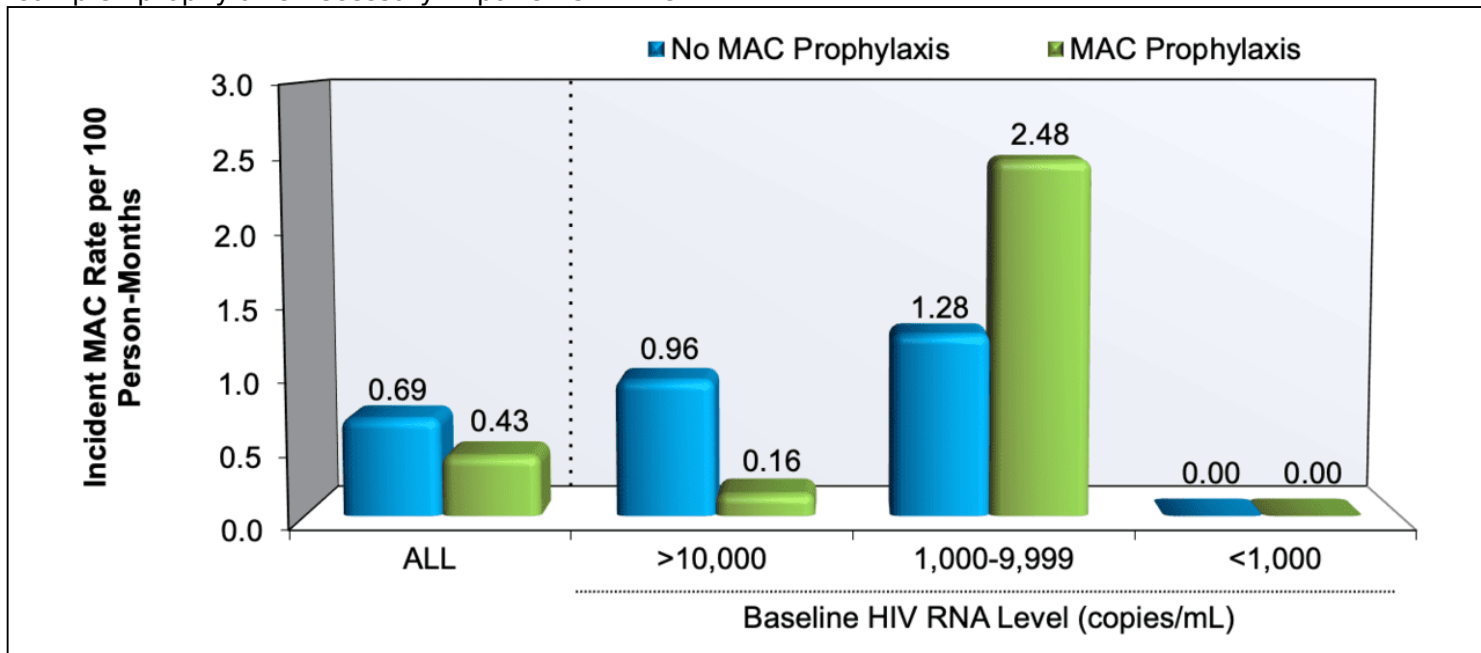


Figure 7 Endemic Regions for Histoplasmosis in United States

Source: Centers for Disease Control and Prevention (CDC)

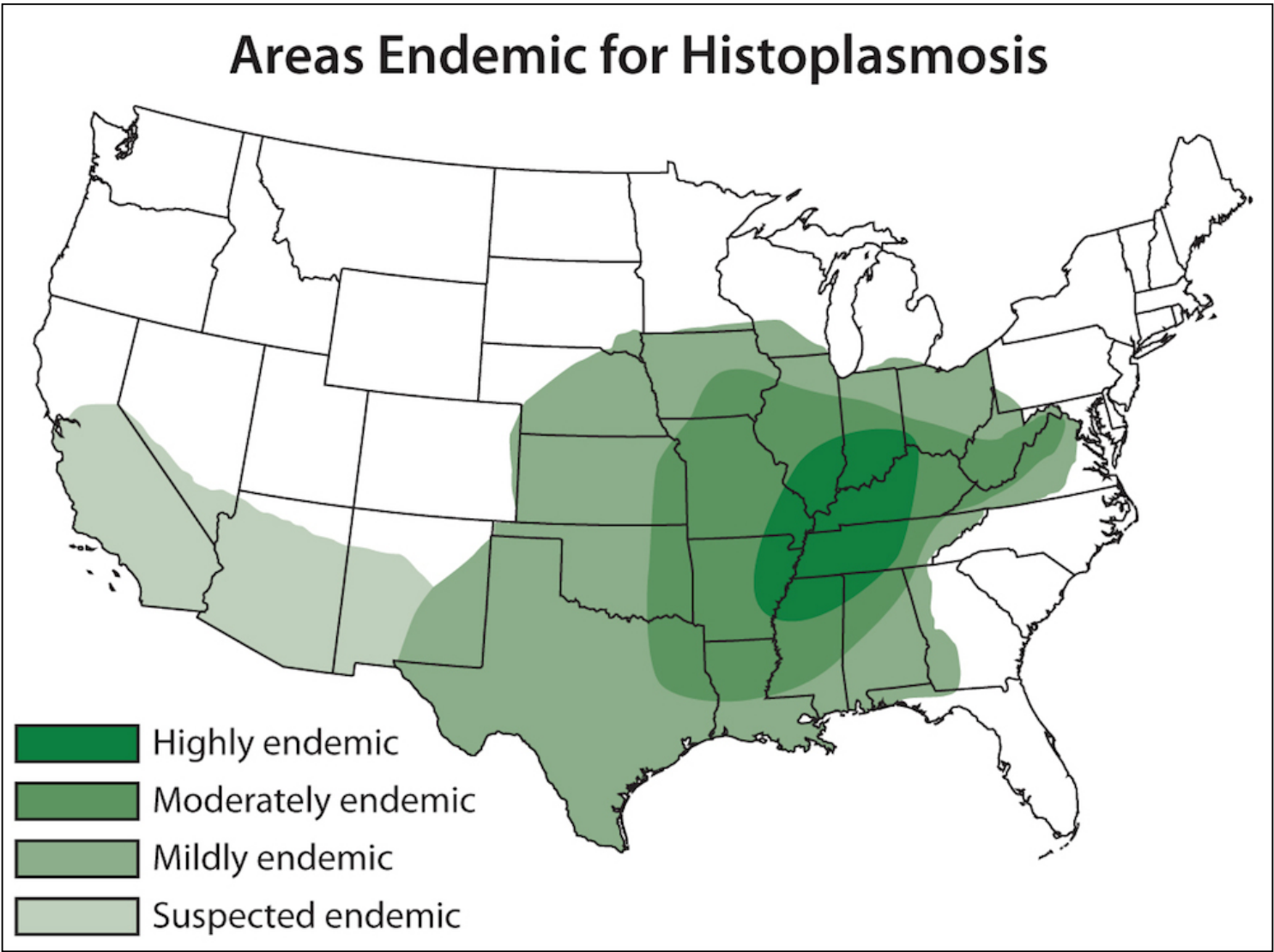


Figure 8 Histoplasmosis: Life Cycle

In the environment, *Histoplasma capsulatum* exists as a mold (1) with aerial hyphae. The hyphae produce macroconidia and microconidia (2) spores that are aerosolized and dispersed. Microconidia are inhaled into the lungs by a susceptible host (3). The warmer temperature inside the host signals a transformation to an oval, budding yeast (4). The yeast are phagocytized by immune cells and transported to regional lymph nodes (5). From there they travel in the blood to other parts of the body (6).

Source: Centers for Disease Control and Prevention (CDC)

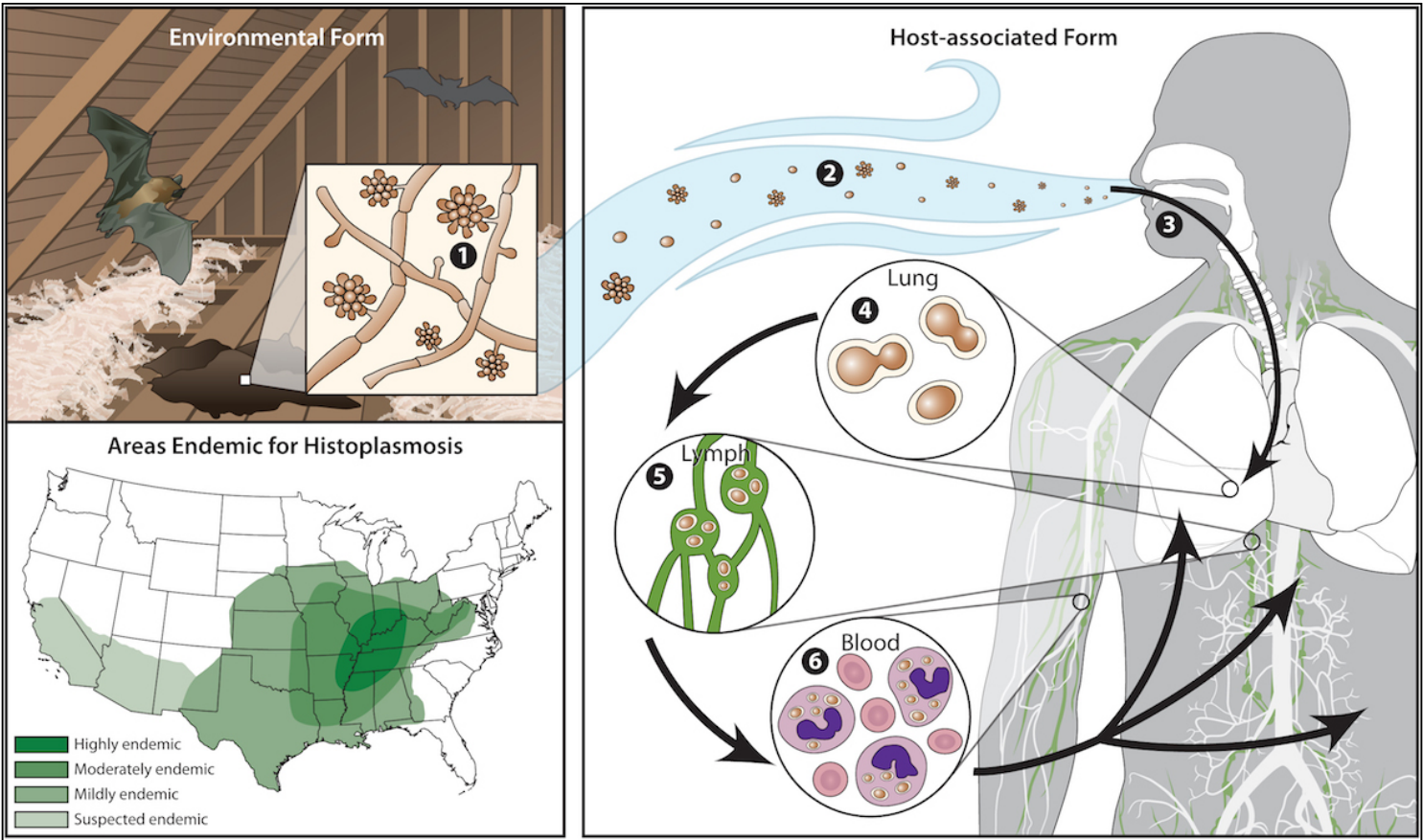


Figure 9 Endemic Regions for Coccidioidomycosis in United States

This map is based on studies performed in the late 1940s and 1950s and also on locations of more recent outbreaks and cases. Coccidioides might also live in similar areas with hot, dry climates that are not shaded on the map.

Source: Centers for Disease Control and Prevention (CDC)

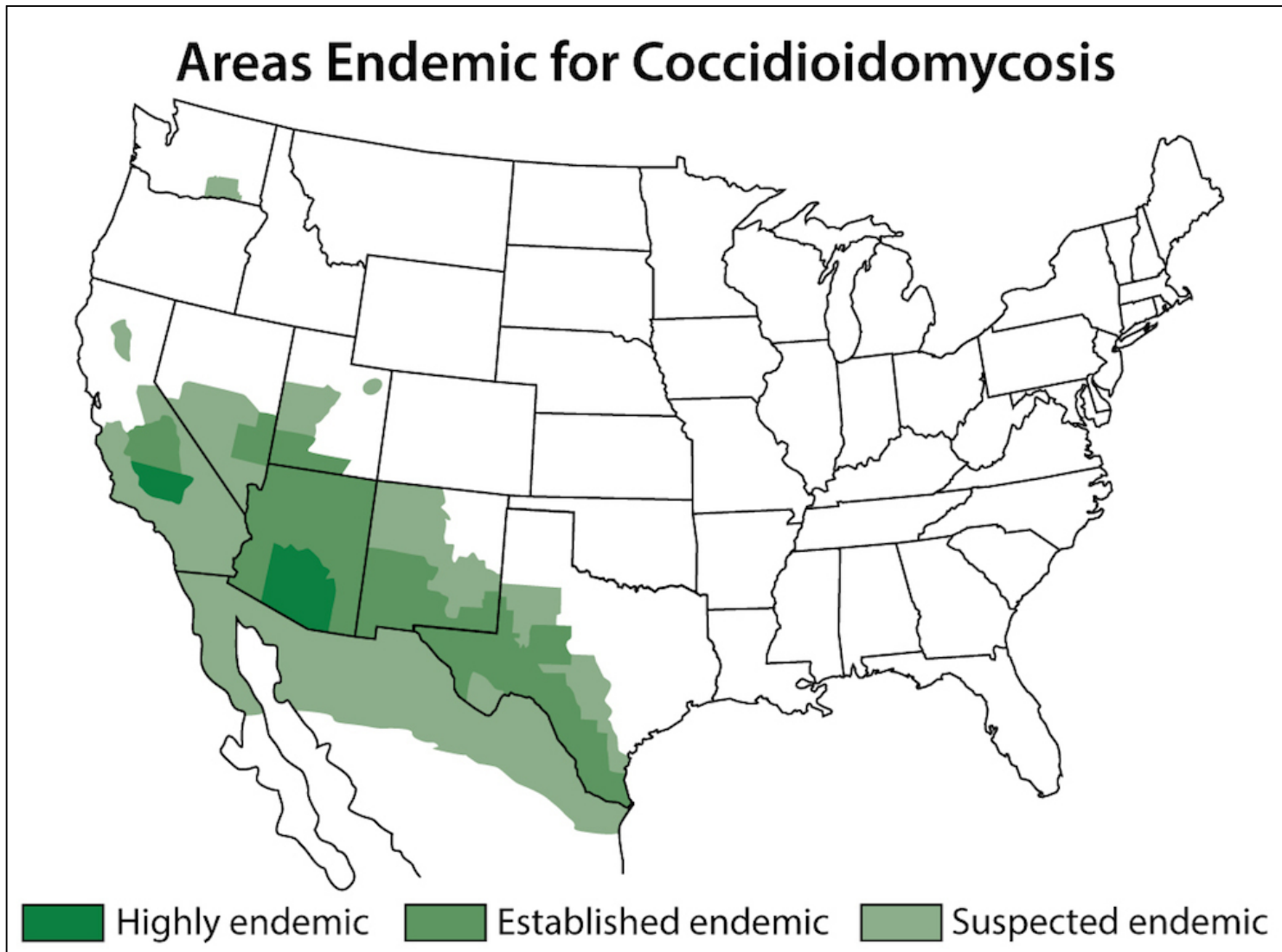


Figure 10 Coccidioidomycosis: Life Cycle

In the environment, *Coccidioides* spp. exists as a mold (1) with septate hyphae. The hyphae fragment into arthroconidia (2), which measure only 2-4 μm in diameter and are easily aerosolized when disturbed (3). Arthroconidia are inhaled by a susceptible host (4) and settle into the lungs. The new environment signals a morphologic change, and the arthroconidia become spherules (5). Spherules divide internally until they are filled with endospores (6). When a spherule ruptures (7) the endospores are released and disseminate within surrounding tissue. Endospores are then able to develop into new spherules (6) and repeat the cycle.

Source: Centers for Disease Control and Prevention (CDC)

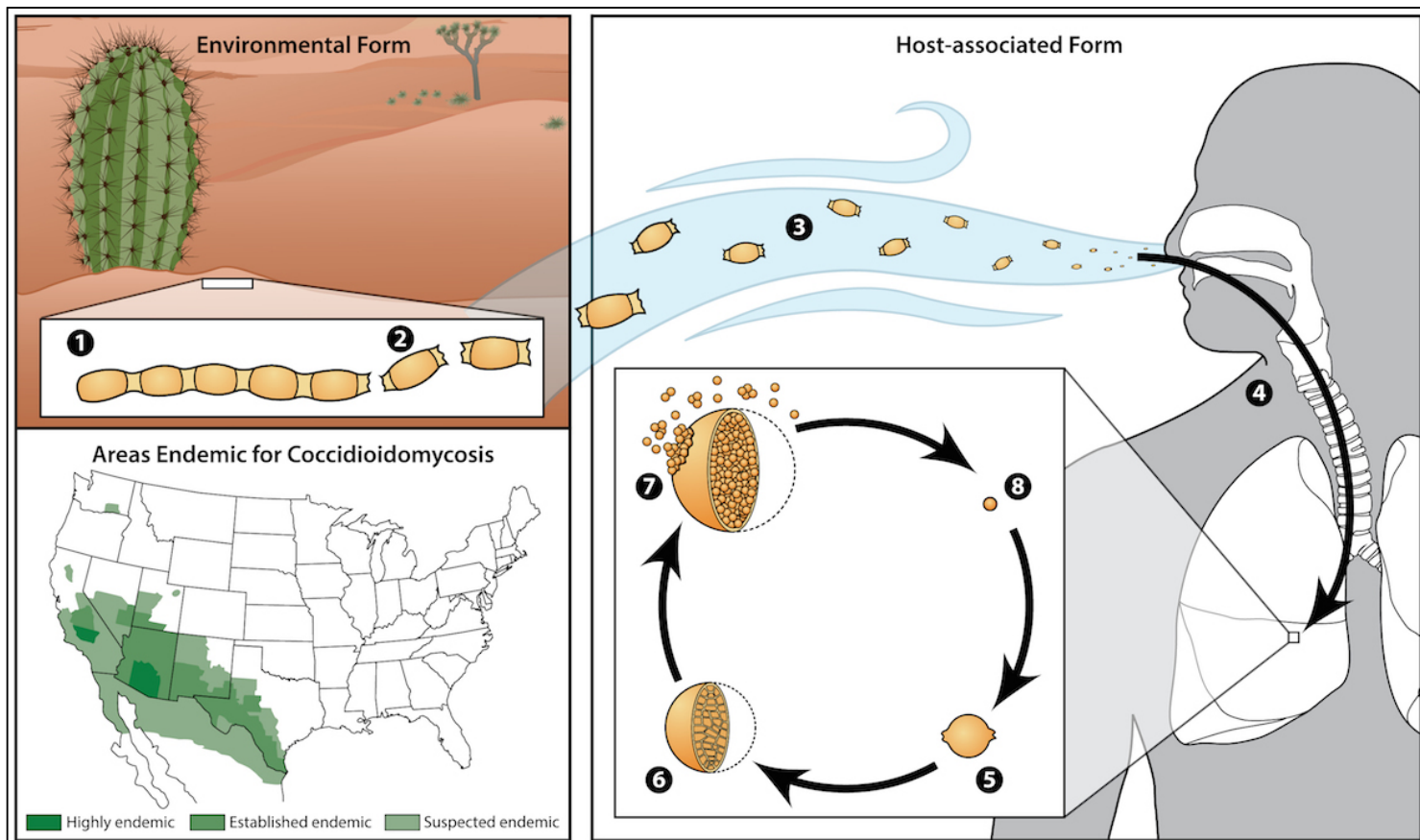


Table 1. Guidelines for the Prevention and Treatment of Opportunistic Infections in Adults and Adolescents with HIV

Regimens for *Pneumocystis* Pneumonia Primary Prophylaxis

Preferred Therapy:

- Trimethoprim-sulfamethoxazole, 1 DS PO daily^a (AI) *or*
- Trimethoprim-sulfamethoxazole, 1 SS PO daily^a (AI).

Alternative Therapy:

- Trimethoprim-sulfamethoxazole 1 DS PO three times weekly (BI) *or*
- Dapsone^{b,c} 100 mg PO daily or 50 mg PO twice daily (BI) *or*
- Dapsone^b 50 mg PO daily + (pyrimethamine 50 mg + leucovorin 25 mg) PO weekly (BI) *or*
- (Dapsone^b 200 mg + pyrimethamine 75 mg + leucovorin 25 mg) PO weekly (BI) *or*
- Aerosolized pentamidine^c 300 mg via Respigard II™ nebulizer every month (BI) *or*
- Atovaquone 1500 mg PO daily with food (BI) *or*
- (Atovaquone 1500 mg + pyrimethamine 25 mg + leucovorin 10 mg) PO daily with food (CIII)

^a Trimethoprim-sulfamethoxazole DS once daily also confers protection against toxoplasmosis and many respiratory bacterial infections; lower dose also likely confers protection.

^b Whenever possible, patients should be tested for G6PD deficiency before administration of dapsone or primaquine. Alternative agent should be used if the patient is found to have G6PD deficiency.

^c Aerosolized pentamidine or dapsone (without pyrimethamine) should not be used for PCP prophylaxis in patients who are seropositive for *Toxoplasma gondii*.

Key to Acronyms: DS = double strength; PO = orally; SS = single strength.

Rating System for Prevention and Treatment Recommendations

- Strength of Recommendation: A = Strong; B = Moderate; C = Optional
- Quality of Evidence for the Recommendation: I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, non-randomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

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. *Pneumocystis* Pneumonia. Updated: March 28, 2019. [HIV.gov]

Table 2. Guidelines for the Prevention and Treatment of Opportunistic Infections in Adults and Adolescents with HIV

Regimens for *Toxoplasma* Encephalitis Primary Prophylaxis

Preferred Regimen:

- Trimethoprim-sulfamethoxazole, 1 DS PO daily (AII)

Alternative Regimens:

- Trimethoprim-sulfamethoxazole 1 DS tablet PO three times weekly (BIII), *or*
- Trimethoprim-sulfamethoxazole SS tablet PO daily (BIII), *or*
- Dapsone^a 50 mg PO daily plus (pyrimethamine 50 mg plus leucovorin 25 mg) PO weekly (BI), *or*
- (Dapsone^a 200 mg plus pyrimethamine 75 mg plus leucovorin 25 mg) PO weekly (BI), *or*
- Atovaquone^b 1500 mg PO daily (CIII), *or*
- (Atovaquone^b 1500 mg plus pyrimethamine 25 mg plus leucovorin 10 mg) PO daily (CIII)

^aWhenever possible, patients should be tested for G6PD deficiency before administering dapsone. Alternative agent should be used if the patient is found to have G6PD deficiency.

^bAtovaquone should be taken with meals or nutritional supplement to ensure adequate oral absorption. Key to Acronyms: DS = double strength; PO = orally; SS = single strength.

Rating System for Prevention and Treatment Recommendations

- Strength of Recommendation: A = Strong; B = Moderate; C = Optional
- Quality of Evidence for the Recommendation: I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, non-randomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

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. *Toxoplasma gondii* encephalitis. Updated: July 25, 2017. [HIV.gov]

Table 3. Guidelines for the Prevention and Treatment of Opportunistic Infections in Adults and Adolescents with HIV

Regimens for Disseminated MAC Primary Prophylaxis

Preferred Therapy:

- Azithromycin 1200 mg PO once weekly (AI), *or*
- Clarithromycin 500 mg PO twice daily (AI), *or*
- Azithromycin 600 mg PO twice weekly (BIII)

Alternative Therapy:

- Rifabutin 300 mg PO daily (BI) (dosage adjusted may be necessary based on drug-drug interactions)

Note: Active TB should be ruled out before starting rifabutin

Key to Acronyms: MAC = *Mycobacterium avium* complex; PO = orally.

Rating System for Prevention and Treatment Recommendations

- Strength of Recommendation: A = Strong; B = Moderate; C = Optional
- Quality of Evidence for the Recommendation: I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, non-randomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion

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. *Mycobacterium avium* complex disease. Updated: February 15, 2019. [HIV.gov]

