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# Opportunistic Infections: Prevention

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| Module 4: | Co-Occurring Conditions |
| Lesson 2: | Opportunistic Infections: Prevention |

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## 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, and these declines involved all major AIDS-defining opportunistic infections (Figure 1).[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.[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/mm$^3$.[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 100-200 cells/mm$^3$, if plasma HIV RNA level above detection limits (**AI**), *or*
- CD4 count less than 100 cells/mm$^3$, regardless of plasma HIV RNA level (**AIII**)

Note: Individuals receiving pyrimethamine and sulfadiazine for the prevention or treatment for toxoplasmosis 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 as outlined in the table below.[8] (Table 1)

- **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 (*Toxoplasma* antibody-positive and CD4 count less than 100 cells/mm$^3$).[10] Several studies suggest lower doses of trimethoprim-sulfamethoxazole also provide adequate protection against *Toxoplasma* encephalitis.[11,12] 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.[13]

## Pregnancy Considerations

- Clinicians providing pre-pregnancy care for women receiving *Pneumocystis* prophylaxis should consider discussing the option of postponing pregnancy until it is safe to discontinue *Pneumocystis*vprophylaxis (**BIII**).[8]
- The criteria for initiating *Pneumocystis* prophylaxis in pregnant women is the same as in nonpregnant adults (**AIII**).[8]
- Trimethoprim-sulfamethoxazole is the recommended *Pneumocystis* prophylaxis medication in pregnancy (**AIII**).[8] Folic acid may be concomitantly given to women of child-bearing potential who

need *Pneumocystis* prophylaxis. Folic acid should ideally be started pre-pregnancy or as soon as possible in the first trimester.[8] Due to potential teratogenic risks from first-trimester use of trimethoprim-sulfamethoxazole, clinicians might opt for alternative prophylactic regimens, such as aerosolized pentamidine or oral atovaquone, instead of withholding chemoprophylaxis during this period (**CIII**).[8]

## Discontinuing Primary Prophylaxis

Primary prophylaxis against *Pneumocystis* pneumonia should be discontinued when possible to reduce pill burden, minimize risk of drug toxicity, and prevent the selection of antibiotic-resistant pathogens, especially if using trimethoprim-sulfamethoxazole. 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/mm$^3$ to 200 cells/mm$^3$ 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/mm$^3$.[14,15,16]
- Can consider if the CD4 count is 100 to 200 cells/mm$^3$ 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/mm$^3$ who stopped or never took *Pneumocystis* pneumonia prophylaxis if they had suppressed HIV RNA levels.[17,18,19]

## Restarting Primary Prophylaxis

Primary prophylaxis for *Pneumocystis* pneumonia should be restarted if (1) the CD4 count declines to less than 100 cells/mm$^3$ regardless of HIV RNA level or (2) if the CD4 count is 100 to 200 cells/mm$^3$ and the HIV RNA is consistently above the detection limit of the assay.[8]

## Adverse Effects of Medications Used for *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.[20] 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.[20] Depending on the adverse effects experienced, supportive care should be attempted prior to discontinuation of the drug rechallenge 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).[21] Prior to starting dapsone once daily, most experts recommend checking a glucose-6-phosphate dehydrogenase (G6PD) level since dapsone may trigger hemolytic anemia in patients who have G6PD deficiency.[12,22,23]
- **Atovaquone**: Atovaquone causes few serious adverse effects, but the liquid formulation can be difficult for patients due to the bad taste.[24,25]
- **Aerosolized Pentamidine**: Aerosolized pentamidine can induce cough and bronchospasm, but it is

generally well tolerated.[26,27]

- **Intravenous Pentamidine**: Caution should be used if administering intravenous pentamidine due to multiple potential serious adverse effects, including hypotension, hypoglycemia, cardiac arrhythmias, and nephrotoxicity.[26,27]

# *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 2).[10] Most cases of toxoplasmosis in persons with HIV result from reactivation of latent *T. gondii* cysts in the brain 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/mm$^3$ was 40 per 1,000 person-years; this rate has declined to a very low level due to widespread use of antiretroviral therapy and trimethoprim-sulfamethoxazole for *Pneumocystis* pneumonia prophylaxis.[28]

## Preventing Acquisition of *Toxoplasma gondii*

Individuals with HIV, particularly those with a CD4 count less than 200 cells/mm$^3$, should receive counseling on how to prevent infection with *T. gondii*, unless they are known to already have a positive *T. gondii* antibody test. To prevent acquisition of *T. gondii*, 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.[10]

## Indications for Initiating Primary Prophylaxis

Persons with HIV should have testing for IgG antibody to *T. gondii* as soon as possible after the initial diagnosis of HIV if their CD4 count is less than 200 cells/mm$^3$.[10] 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.[10]

- Persons with HIV and a CD4 count less than 100 cells/mm$^3$ who are also seropositive (IgG) for *Toxoplasma* (**AII**).

## Recommended Regimens for Primary Prophylaxis

The following table summarizes the Adult and Adolescent OI Guidelines recommendations for *Toxoplasma* encephalitis prophylaxis.[10] Note that all recommended regimens for *Toxoplasma* encephalitis prophylaxis are also effective for *Pneumocystis* pneumonia prophylaxis.[10] (Table 2).

## Discontinuing Primary Prophylaxis

The Adult and Adolescent OI Guidelines list the following indications for discontinuation of primary *Toxoplasma* encephalitis prophylaxis.[10]

- CD4 count greater than 200 cells/mm$^3$ for more than 3 months in response to antiretroviral therapy (**AI**), *or*
- Can consider if the CD4 count is 100 to 200 cells/mm$^3$ 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/mm$^3$ for more than 3 months).[29,30,31,32,33] 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/mm$^3$, regardless of the HIV RNA level.[10] For those individuals with a CD4 of 100 to 200 cells/mm$^3$ who do not have viral suppression, primary *Toxoplasma* prophylaxis should be resumed (along with *Pneumocystis* pneumonia prophylaxis) (**AIII**).[10]

# 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.[34] *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/mm$^3$.[35,36,37] In the era prior to the 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.[2,3] A retrospective analysis of 369 patients with a CD4 count less than 50 cells/mm$^3$ (and no history of MAC infection) 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 3).[38] 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.[39]

- 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/mm$^3$ if they promptly started on antiretroviral therapy and achieved virologic suppression.[38,40,41]
- Persons with HIV who have a CD4 count less than 50 cells/mm$^3$ 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 as outlined in the table below. Note that if MAC prophylaxis is used, most clinicians prefer azithromycin over clarithromycin due to better tolerance, fewer drug interactions, and more convenient dosing.[39](Table 3).[39]

## Discontinuing Primary Prophylaxis

Primary MAC prophylaxis may be discontinued if the following criterion is met:[39]

- 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/$mm^3$.[39]

# 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.[42,43] 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.[44] 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.[45] In either situation, patients with cryptococcal meningitis usually have a CD4 count less than 100 cells/mm$^3$.

## 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/mm$^3$ 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.[46,47] Further analysis showed the rate was 4.3% among those with a CD4 count less than or equal to 50 cells/mm$^3$ compared with 1.7% in those with a CD4 count of 51 to 100 cells/mm$^3$.[48] Based on these data, the Adult and Adolescent OI Guidelines recommend the following regarding cryptococcal antigen screening.[49]

- Serum cryptococcal antigen (CrAg) surveillance is recommended for persons with HIV who have a CD4 count less than 200 cells/mm$^3$ (particularly those with a CD4 count less than or equal to 50 cells/mm$^3$); there are no recommendations regarding the recommended frequency of this surveillance. The serum CrAg assay is usually performed using a lateral flow assay (LFA); other commonly used assays include an enzyme immunoassay (EIA) and a latex agglutination test.

## Management of Asymptomatic Cryptococcal Antigenemia

If the serum CrAg screening test is positive and the person is asymptomatic, they can safely be treated without performing a lumbar puncture if they are taking antiretroviral therapy and the serum cryptococcal antigen titer is

# 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.[53,54,55,56] 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/mm$^3$.[57,58] In persons with HIV, retinitis is the most common manifestation of CMV-related end-organ disease.[56,57] 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.[58] 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.[3,59,60,61]

## 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.[58] In the ACTG A5030 trial, preemptive valganciclovir therapy was evaluated for individuals with a CD4 count less than 100 cells/mm$^3$ (on stable antiretroviral therapy) and CMV viremia, but this strategy of preemptive therapy was not protective.[61] 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.[58]

## 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/mm$^3$ every 3 to 4 months (and some recommend performing this screening when the CD4 count is less than 100 cells/mm$^3$).[58] 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.[58]

# Histoplasmosis

## Background

Histoplasmosis is a fungal infection caused by *Histoplasma capsulatum*, which is the most common endemic mycosis in the United States (Figure 4).[62,63] 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.[62,64] 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. 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/mm$^3$.[65] 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.[66]

## Preventing Exposure

The Adult and Adolescent OI Guidelines recommend that persons with HIV who have a CD4 count less than 200 cells/mm$^3$ 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**).[67]

## 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.[50] The Adult and Adolescent OI Guidelines note that some experts recommend the following as an indication for histoplasmosis primary prophylaxis.[67]

- CD4 count less than 150 cells/mm$^3$ 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/mm$^3$ or greater for at least 6 months

(BIII). Primary prophylaxis should be restarted if the CD4 count drops below 150 cells/$mm^3$ (**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/$mm^3$ and live (or have lived) in a region endemic for coccidioidomycosis.[68] 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. 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 5). Only a low inoculum of arthroconidia are needed to establish infection.[69] 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.[70]

## 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**).[68]

## 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**).[68]

## 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.[68] Serologic testing is also recommended for persons who have previously lived (or extensively traveled) to a region endemic for coccidioidomycosis.[68] Routine coccidioidal serologic screening is not recommended for asymptomatic individuals who have not lived in or traveled to endemic areas.[68] 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.[68]

## Initiation of Primary Prophylaxis/Pre-Emptive Therapy

The following three criteria should be met for initiating coccidioidomycosis primary prophylaxis/pre-emptive therapy:

- New positive IgM and/or IgG test for *Coccidioides, and*
- No sign of active coccidioidomycosis, *and*
- CD4 count less than 250 cells/$mm^3$

Note: The Adult and Adolescent OI Guidelines do not clarify the approach for a person who tests positive for

coccidioidomycosis, but no prior serologic testing (making it unclear whether the results truly represent a new positive test).[68]

## Preferred Regimen for Primary Prophylaxis/Pre-Emptive Therapy

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

## Discontinuing Primary Prophylaxis/Pre-Emptive Therapy

If fluconazole is administered to prevent active coccidioidomycosis disease, it should be continued until the CD4 count is 250 cells/$mm^3$ or higher and HIV RNA levels are consistently suppressed (**BIII**).[68]

## 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/$mm^3$ 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 generating drug resistance.

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# Figures

**Figure 1 (Image Series) - AIDS-Defining Opportunistic Illnesses in the United States (Image Series) - Figure 1 (Image Series) - AIDS-Defining Opportunistic Illnesses in the United States Image 1A: 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.

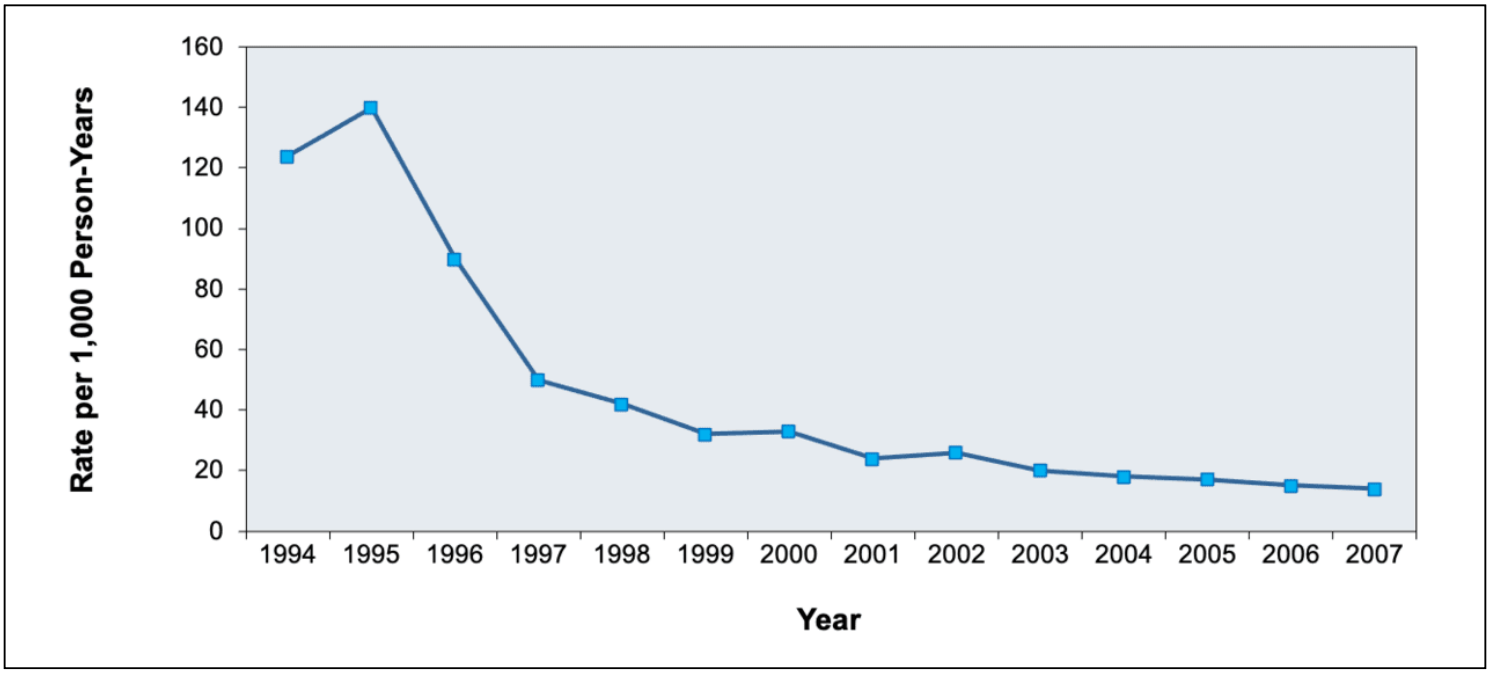

**Figure 1 (Image Series) - AIDS-Defining Opportunistic Illnesses in the United States**
**Image 1B: AIDS-Defining Opportunistic Illnesses, HIV Outpatient Cohort Study, 1994–2007**

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.

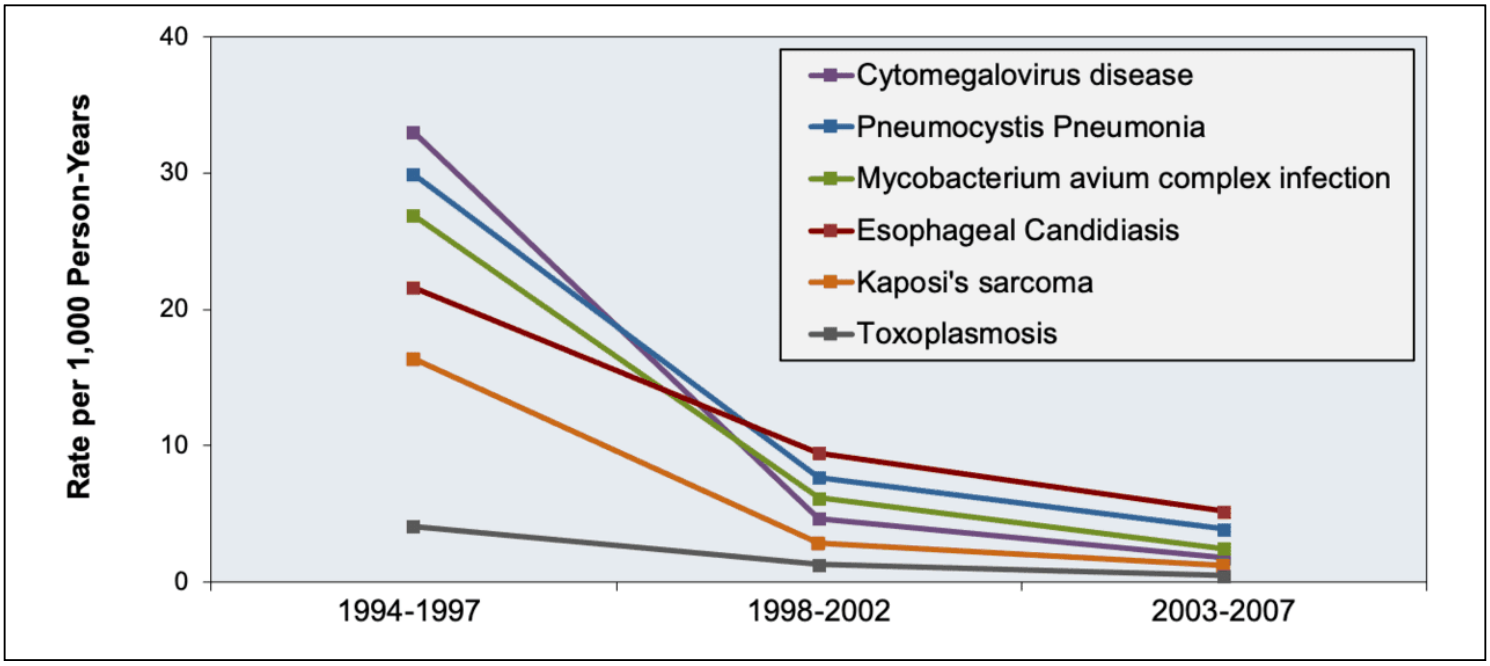

**Figure 1 (Image Series) - AIDS-Defining Opportunistic Illnesses in the United States**
**Image 1C: AIDS-Defining Opportunistic Illnesses in United States and Canada, NA-ACCORD, 2000–2010**

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.

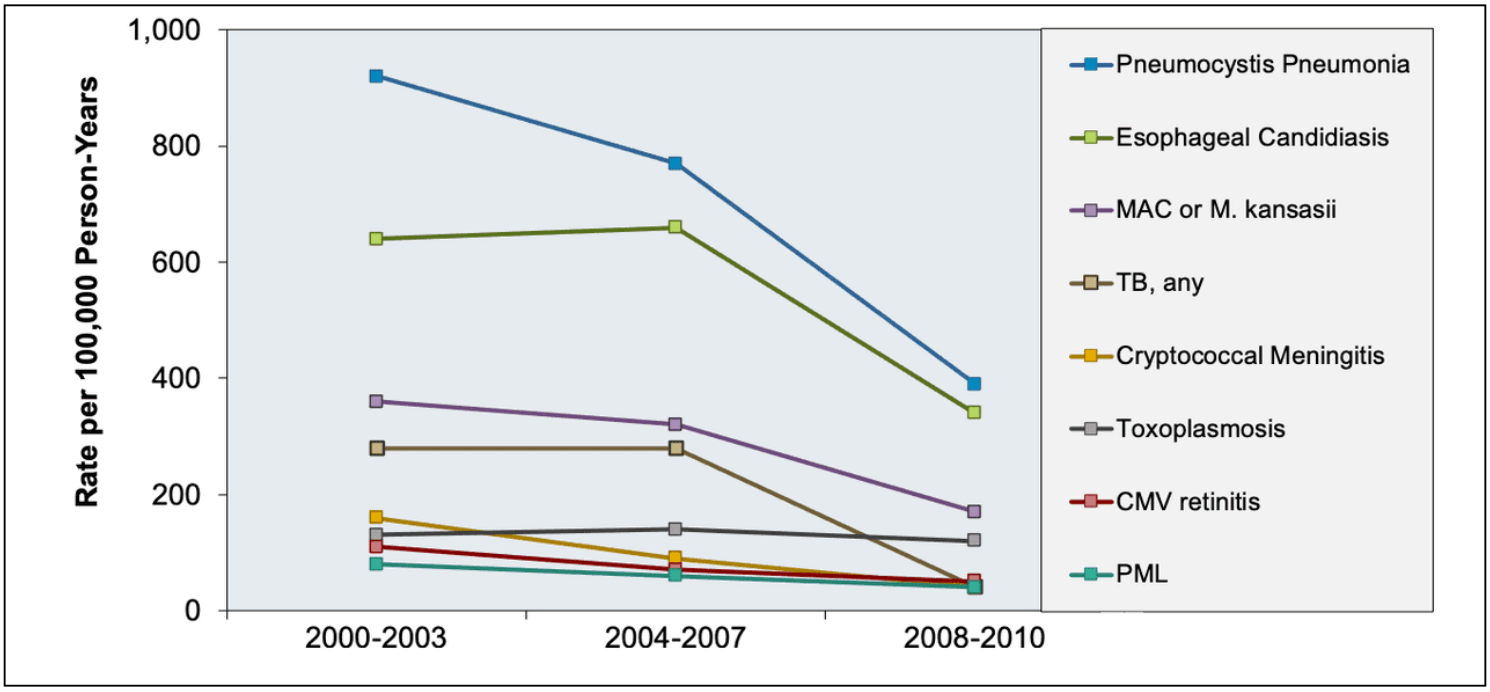

**Figure 2 *Toxoplasma gondii* Life Cycle and Human Infection**

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.

Illustration by David Ehlert, Cognition Studio, Inc.

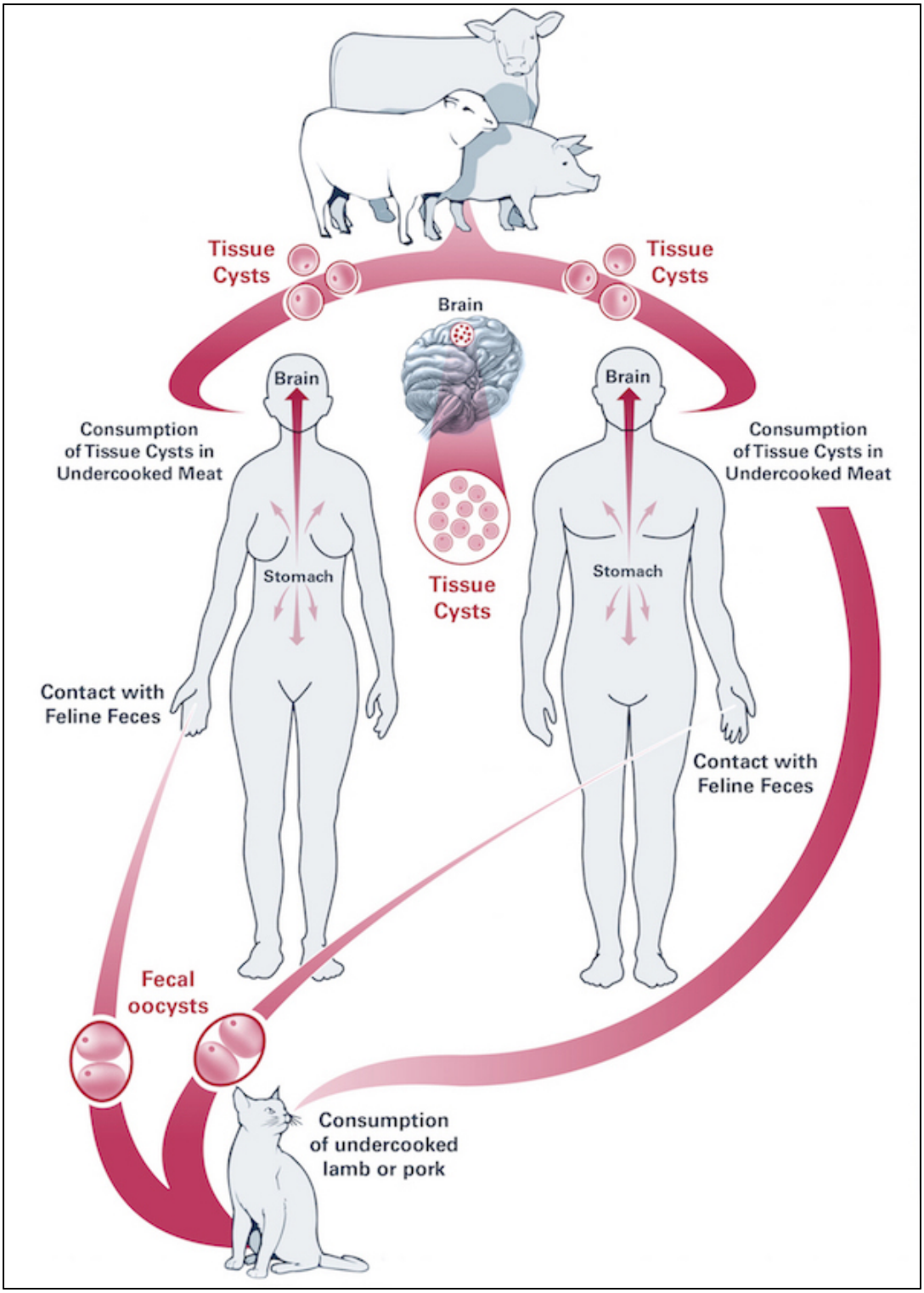

**Figure 3 *Mycobacterium avium* Complex Infection Risk in the HIV Outpatient Study, 1996-2007**

All patients had a CD4 count of less than 50 cells/mm$^3$ at the time of enrollment and all were prescribed antiretroviral therapy.

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

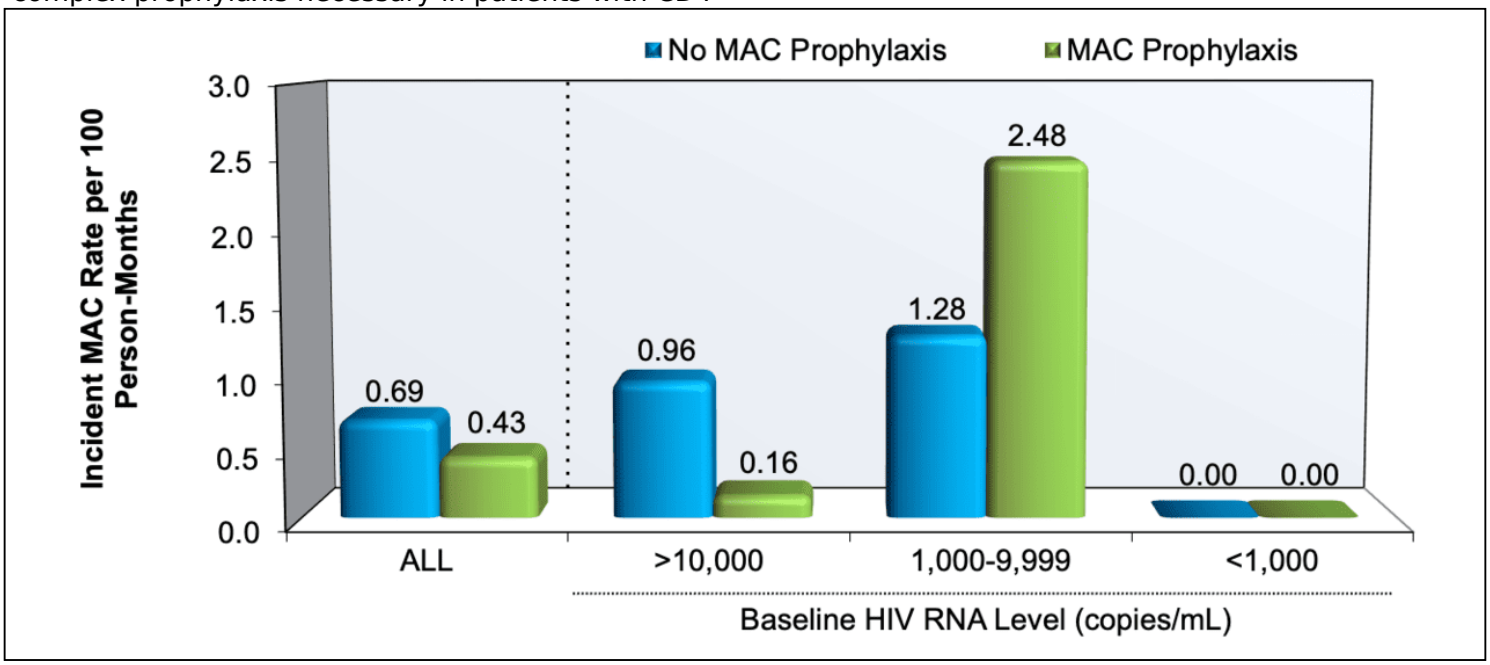

**Figure 4 (Image Series) - Histoplasmosis Endemic Regions in United Sates and Life Cycle (Image Series) - Figure 4 (Image Series) - Histoplasmosis Endemic Regions in United Sates and Life Cycle**
**Image 4A: Endemic Regions for Histoplasmosis in United States**

Source: Centers for Disease Control and Prevention (CDC)

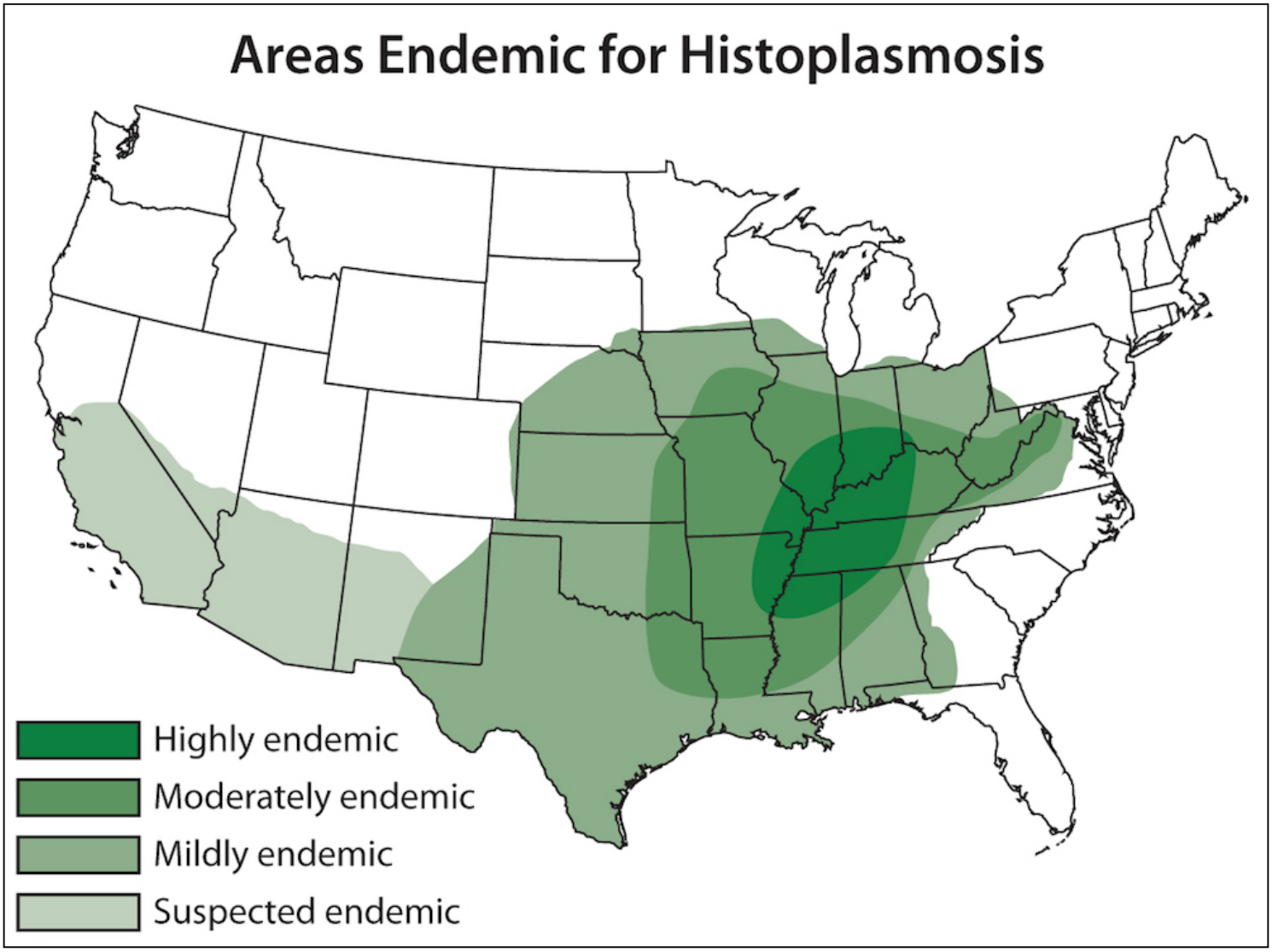

**Figure 4 (Image Series) - Histoplasmosis Endemic Regions in United Sates and Life Cycle**
**Image 4B: Histoplasmosis: Life Cycle**

n 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)

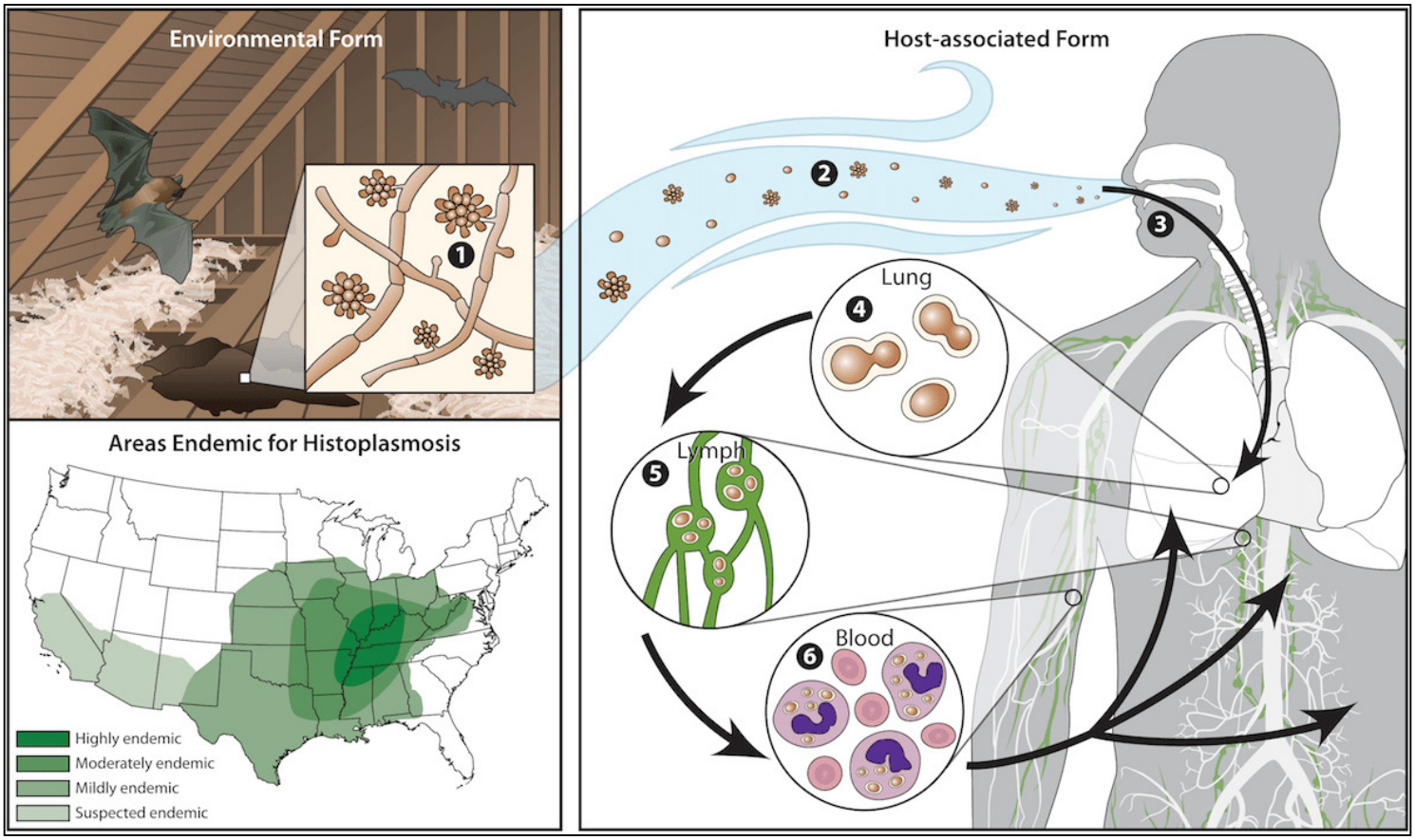

**Figure 5 (Image Series) - Coccidioidomycosis Endemic Regions in United Sates and Life Cycle (Image Series) - Figure 5 (Image Series) - Coccidioidomycosis Endemic Regions in United Sates and Life Cycle**
**Image 5A: Endemic Regions for Coccidioidomycosis in United States**

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)

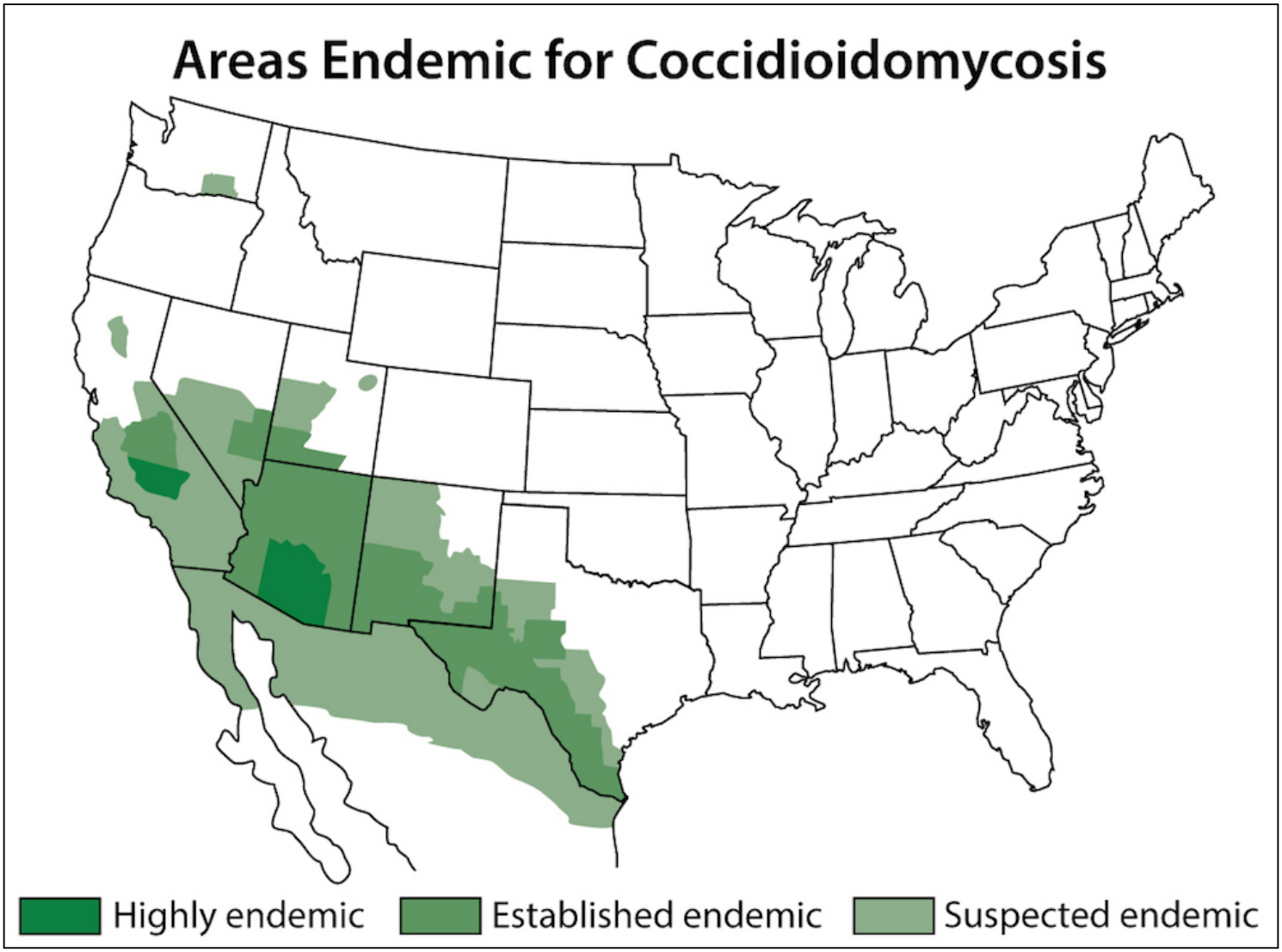

**Figure 5 (Image Series) - Coccidioidomycosis Endemic Regions in United Sates and Life Cycle**
**Image 5B: Coccidioidomycosis: Life Cycle**

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)

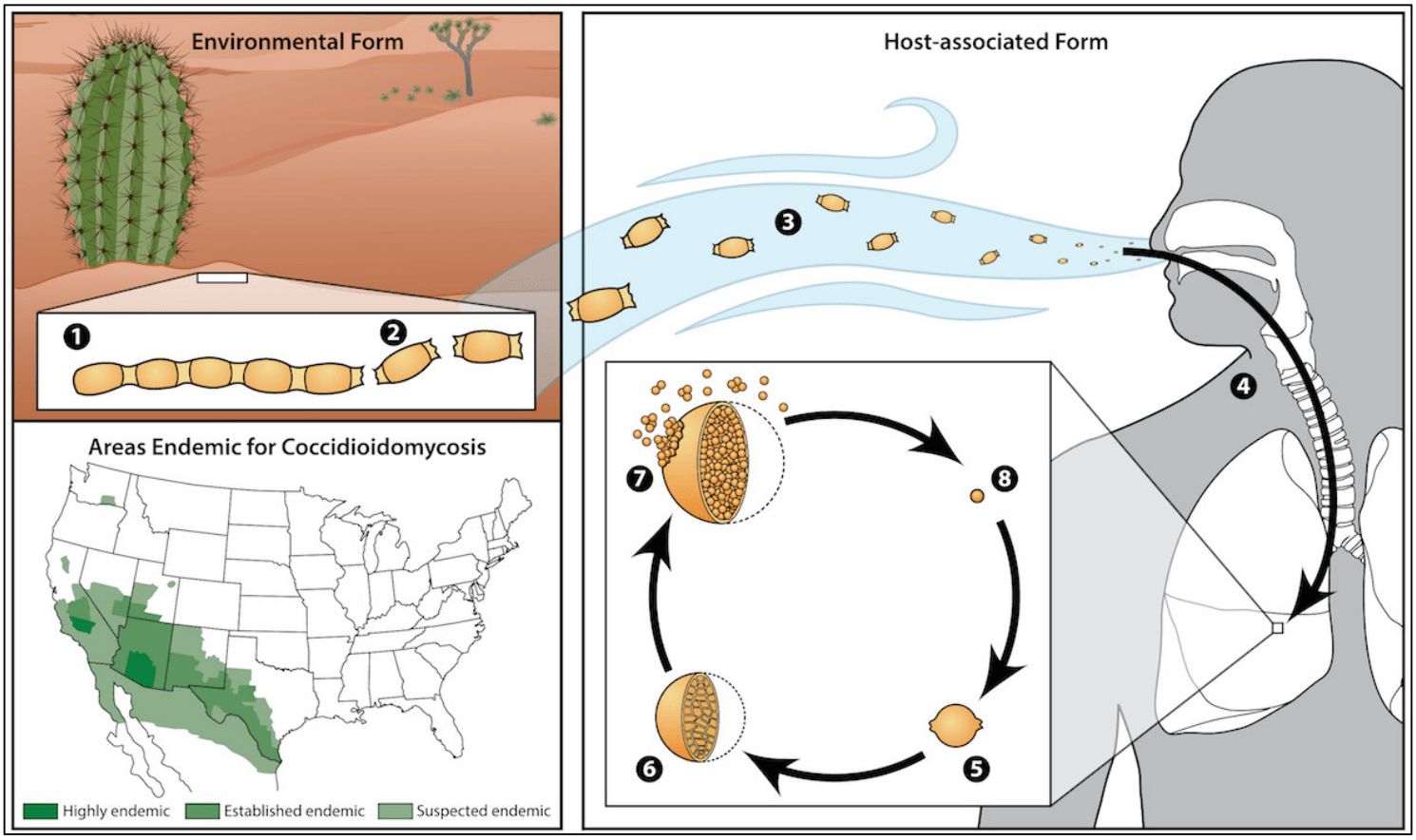

Table 1. **Guidelines for the Prevention and Treatment of Opportunistic Infections in Adults and Adolescents with HIV**

**Regimens for *Pneumocystis* Pneumonia Primary Prophylaxis**

**Preferred Therapy:**

- Trimethoprim-sulfamethoxazole, 1 DS tablet PO daily (AI) *or*
- Trimethoprim-sulfamethoxazole, 1 SS tablet PO daily (AI)

Note: Trimethoprim-sulfamethoxazole also confers protection against toxoplasmosis and some protection against many respiratory bacterial infections.

**Alternative Therapy:**

- The following regimens can be used for people who are seropositive or seronegative for *Toxoplasma gondii*:
  - Trimethoprim-sulfamethoxazole 1 DS PO three times weekly (BI), *or*
  - Dapsone[a] 50 mg PO daily with pyrimethamine 50 mg PO weekly *plus* leucovorin 25 mg PO weekly (BI), *or*
  - Dapsone[a] 200 mg PO weekly with pyrimethamine 75 mg PO weekly *plus* leucovorin 25 mg PO weekly (BI), *or*
  - Atovaquone 1500 mg PO daily with food (BI)
- The following regimens should only be used for people who are seronegative for *Toxoplasma gondii*
  - Dapsone[a] 100 mg PO daily or 50 mg PO twice daily (BI), *or*
  - Aerosolized pentamidine 300 mg via Respigard II™ nebulizer every month (BI), *or*
  - Intravenous Pentamidine 300 mg every 28 days (CIII)

[a] Patients should be tested for glucose-6-phosphate dehydrogenase (G6PD) deficiency before administration of dapsone. An alternative agent should be used if the patient is found to have G6PD deficiency.
Abbreviation: DS = double strength; PO = orally; SS = single strength.

Rating System for Prevention and Treatment Recommendations

- Strength of Recommendation: A = Strong; B = Moderate; C = Weak
- 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: September 16, 2024. [HIV.gov]

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

**Regimens for *Toxoplasma gondii* Encephalitis Primary Prophylaxis**

**Preferred Regimen:**

- Trimethoprim-sulfamethoxazole, one DS tablet PO daily (AII)

**Alternative Regimens:**

- Trimethoprim-sulfamethoxazole one DS tablet PO three times weekly (BIII), *or*
- Trimethoprim-sulfamethoxazole one 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 PO weekly *plus* (pyrimethamine 75 mg *plus* leucovorin 25 mg) PO weekly (BI), *or*
- Atovaquone[b] 1,500 mg PO daily (CIII), *or*
- Atovaquone[b] 1,500 mg PO daily *plus* (pyrimethamine 25 mg *plus* leucovorin 10 mg) PO daily (CIII)

[a]Patients should be tested for glucose-6-phosphate dehydrogenase (G6PD) deficiency before administrating dapsone. An alternative agent should be used if the patient is found to have G6PD deficiency.
[b]Atovaquone should be taken with meals or nutritional supplement to ensure adequate oral absorption.
Abbreviations: DS = double strength; PO = orally; SS = single strength.

Rating System for Prevention and Treatment Recommendations

- Strength of Recommendation: A = Strong; B = Moderate; C = Weak
- 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. *Toxoplasmosis*. Updated: September 16, 2024. [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) in people who cannot tolerate azithromycin or clarithromycin
- Dose adjustment of rifabutin may be necessary based on drug–drug interactions,

Note: Active TB should be ruled out before starting rifabutin

Abbreviations: MAC = *Mycobacterium avium* complex; PO = orally.

Rating System for Prevention and Treatment Recommendations

- Strength of Recommendation: A = Strong; B = Moderate; C = Weak
- 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: August 15, 2024. [HIV.gov]