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Human immune system aging results in impaired responses to pathogens or vaccines. In the innate immune system, which mediates the earliest pro-inflammatory responses to immunologic challenge, processes ranging from Toll-like Receptor function to Neutrophil Extracellular Trap formation are generally diminished in older adults. Dysregulated, enhanced basal inflammation with age reflecting activation by endogenous damage-associated ligands contributes to impaired innate immune responses. In the adaptive immune system, T and B cell subsets and function alter with age. The control of cytomegalovirus infection, particularly in the T lineage, plays a dominant role in the differentiation and diversity of the T cell compartment.	
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The impact of infectious diseases on older adults is far greater than on younger adults because of significantly higher morbidity and mortality caused by infection. The reasons for this greater impact include factors such as lower physiologic reserve due to age and chronic disease, age-related changes in host defenses, loss of mobility, higher risk for polypharmacy and adverse drug reactions, and being on drugs that increase the risk for infection (e.g., anticholinergic and other sedating medications increase the risk for pneumonia).	
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Antibiotic use is common in older adults, and much of it is deemed unnecessary. Complications of antibiotic use may occur as a consequence of changes in age-related physiology and dosing with resulting drug toxicity and secondary infection. Knowing when it is appropriate to initiate antibiotics may help reduce unnecessary antibiotic use and prevent adverse drug events. Careful attention to antibiotic selection, dosing adjustments, and drug-drug interactions may also help prevent antibiotic-related adverse events.	
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Community-acquired pneumonia is common in the elderly person; its presentation in this population is often confounded by multiple comorbid	

illnesses, including those that result in confusion. Although severity-of-illness scoring systems might aid decision-making, clinical judgment following a careful assessment is key in deciding on the site of care and appropriate therapy.

### **Tuberculosis in Older Adults**

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Shobita Rajagopalan

Tuberculosis (TB) remains one of the world's most lethal infectious diseases. Preventive and control strategies among other high-risk groups, such as the elderly population, continues to be a challenge. Clinical features of TB in older adults may be atypical and confused with age-related diseases. Diagnosis and management of TB in the elderly person can be difficult; treatment can be associated with adverse drug reactions. This article reviews the current global epidemiology, pathogenesis, clinical characteristics, diagnosis, management, and prevention of *Mycobacterium tuberculosis* infection in community-dwelling and institutionalized aging adults.

### **Intraabdominal Infections in Older Adults**

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Ana Berlin and Jason Michael Johanning

Intraabdominal infections represent a diagnostic and therapeutic challenge in the elderly population. Atypical presentations, diagnostic delays, additional comorbidities, and decreased physiologic reserve contribute to high morbidity and mortality, particularly among frail patients undergoing emergency abdominal surgery. While many infections are the result of age-related inflammatory, mechanical, or obstructive processes, infectious complications of feeding tubes are also common. The pillars of treatment are source control of the infection and judicious use of antibiotics. A patient-centered approach considering the invasiveness, risk, and efficacy of a procedure for achieving the desired outcomes is recommended. Structured communication and time-limited trials help ensure goal-concordant treatment.

### **Infectious Diarrhea: Norovirus and *Clostridium difficile* in Older Adults**

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Mary B. White, Shobita Rajagopalan, and Thomas T. Yoshikawa

Norovirus infection usually results in acute gastroenteritis, often with incapacitating nausea, vomiting, and diarrhea. It is highly contagious and resistant to eradication with alcohol-based hand sanitizer. Appropriate preventative and infection control measures can mitigate the morbidity and mortality associated with norovirus infection. *Clostridium difficile* infection is the leading cause of health care-associated diarrhea in the United States. Antibiotic use is by far the most common risk factor for *C difficile* colonization and infection. Appropriate preventive measures and judicious use of antibiotics can help mitigate the morbidity and mortality associated with *C difficile* infection.

### **Urinary Tract Infections in the Older Adult**

523

Lindsay E. Nicolle

Urinary infection is the most common bacterial infection in elderly populations. The high prevalence of asymptomatic bacteriuria in both men and

women is benign and should not be treated. A diagnosis of symptomatic infection for elderly residents of long-term care facilities without catheters requires localizing genitourinary findings. Symptomatic urinary infection is overdiagnosed in elderly bacteriuric persons with nonlocalizing clinical presentations, with substantial inappropriate antimicrobial use. Residents with chronic indwelling catheters experience increased morbidity from urinary tract infection. Antimicrobial therapy is selected based on clinical presentation, patient tolerance, and urine culture results.

## **Herpes Zoster**

539

Kenneth Schmader

Herpes zoster causes significant suffering owing to acute and chronic pain or postherpetic neuralgia (PHN). Varicella-zoster virus–induced neuronal destruction and inflammation causes the principal problems of pain, interference with activities of daily living, and reduced quality of life in older adults. The optimal treatment of herpes zoster requires early antiviral therapy and careful pain management. For patients who have PHN, evidence-based pharmacotherapy using topical lidocaine patch, gabapentin, pregabalin, tricyclic antidepressants, or opiates can reduce pain burden. The live attenuated zoster vaccine is effective in reducing pain burden and preventing herpes zoster and PHN in older adults.

## **Bone and Joint Infections in Older Adults**

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Simon C. Mears and Paul K. Edwards

Bone and joint infections in the elderly patient include septic native joints, osteomyelitis, and prosthetic joint infection. Infections are difficult to treat and require a team approach. Surgical debridement and intravenous antibiotics are the keys to treatment. Prosthetic joint infections often need a two-stage approach to treatment. First the infected joint is removed and the infection treated, then a second prosthetic joint is placed. Prosthetic joint infection is becoming the most common complication after joint replacement surgery. Outcomes of treatment of bone and joint infections are related to the severity of the infection and condition of the host. Because the elderly are often frail, treatment is challenging.

## **Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome in Older Adults**

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Jake Scott and Matthew Bidwell Goetz

Improved survival with combination antiretroviral therapy has led to a dramatic increase in the number of human immunodeficiency virus (HIV)–infected individuals 50 years of age or older such that by 2020 more than 50% of HIV-infected persons in the United States will be above this age. Recent studies confirm that antiretroviral therapy should be offered to all HIV-infected patients regardless of age, symptoms, CD4+ cell count, or HIV viral load. However, when compared with HIV-uninfected populations, even with suppression of measurable HIV replication, older individuals are at greater risk for cardiovascular disease, malignancies, liver disease, and other comorbidities.

**Infections in Nursing Homes: Epidemiology and Prevention Programs**

585

Ana Montoya, Marco Cassone, and Lona Mody

This review summarizes current literature pertaining to infection prevention in nursing home population including post-acute care patients and long-term care residents. Approximately 2 million infections occur each year and more than one-third of older adults harbor multidrug-resistant organisms in this setting. Surveillance, hand hygiene, isolation precautions, resident and employee health programs, education, and antibiotic stewardship are essential elements of infection prevention and control programs in nursing homes. This article discusses emerging evidence suggesting the usefulness of interactive multimodal bundles in reducing infections and antimicrobial resistance, thereby enhancing safety and quality of care for older adults in nursing homes.

**Vaccinations for the Older Adult**

609

Gowrishankar Gnanasekaran, Rex Biedenbender, Harley Edward Davidson, and Stefan Gravenstein

Vaccine response declines with age, but currently recommended vaccines are safe and effective in reducing, if not preventing, disease altogether. Over the last decade, advancements in vaccine immunogenicity, either by increasing dose or conjugating vaccines to protein, have resulted in more immunogenic vaccines that also seem more effective in reducing clinical disease both for influenza and pneumococcus. Meanwhile, there is a resurgence in incident pertussis, exceeding prevalence from five decades ago, adding older adults to a recommended target vaccination group. This article discusses currently available vaccines, in the context of current epidemiology and recommendations, for older adults.

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