

Common Questions About Pneumonia in Nursing Home Residents

CATHERINE CASEY, MD; MELISSA J. FULLERTON, MD; and NICHOLAS SOMERVILLE, MD, MPH
University of Virginia School of Medicine, Charlottesville, Virginia

Pneumonia in older adults residing in nursing homes can be challenging to diagnose and treat. Pneumococcal and influenza immunizations decrease the risk of pneumonia and are recommended for all nursing home patients. Older adults with pneumonia may not display classic signs and symptoms of infection, although most have at least one respiratory symptom. Suspicion of pneumonia is heightened if pulse oximetry measurements are low. The diagnosis of pneumonia is confirmed by chest radiography. To determine whether treatment is necessary and where treatment should occur, the patient's overall prognosis should be considered. If treatment is to occur, antibiotics should be administered as soon as possible for a duration of five to eight days; however, treatment may be extended in the absence of clinical resolution or in the presence of *Pseudomonas aeruginosa*. Oral antibiotics may be administered in the nursing home, whereas hospitalized patients should initially receive intravenous antibiotics and transition to oral antibiotics after clinical improvement. Antibiotic regimens for patients treated in the nursing home include a respiratory fluoroquinolone, or a beta-lactam antibiotic with a macrolide. Hospitalized patients may receive the same regimens, although several other oral and intravenous options are acceptable. Patients' prognosis can be accurately estimated using the SOAR score (which uses systolic blood pressure, oxygenation, age, and respiratory rate). (*Am Fam Physician*. 2015;92(7):612-620. Copyright © 2015 American Academy of Family Physicians.)

CME This clinical content conforms to AAFP criteria for continuing medical education (CME). See CME Quiz Questions on page 565.

Author disclosure: No relevant financial affiliations.

Pneumonia is a common problem in nonventilated adults older than 65 years residing in long-term care facilities, such as nursing homes. The median reported incidence of pneumonia in this population is 1 to 1.2 per 1,000 patient-days.^{1,2} This article summarizes evidence behind answers to the most common questions on diagnosing and treating pneumonia in this patient population. There is controversy, however, about whether the evaluation and treatment of pneumonia in nursing home patients should follow guidelines for health care-associated pneumonia, as suggested by the Infectious Diseases Society of America (IDSA), or for community-acquired pneumonia (CAP), as recommended by the U.K.'s National Institute for Health and Care Excellence (NICE).^{3,4}

Although several recommendations are outlined here, identifying candidates for diagnostic testing and treatment ultimately depends on a patient's overall prognosis, advance directive, and goals of care.

How Effective Is the Pneumococcal Vaccine at Preventing Pneumonia?

Over a two-year period, immunization with the 23-valent pneumococcal polysaccharide vaccine (Pneumovax) prevents one case of pneumonia for every 12 patients immunized in nursing homes. However, neither all-cause nor pneumonia-specific mortality is decreased.⁵ The Advisory Committee on Immunization Practices recommends administering the 13-valent pneumococcal conjugate vaccine (Prevnar 13) in addition to the 23-valent vaccine in patients older than 65 years.⁶ No long-term data are available on whether administration of both vaccines will effectively prevent pneumonia in nursing home residents older than 65 years.

EVIDENCE SUMMARY

Using concealed allocation, 1,006 residents in 26 Japanese nursing homes received the 23-valent pneumococcal polysaccharide vaccine or placebo. Patients were randomized individually, rather than by facility,

SORT: KEY RECOMMENDATIONS FOR PRACTICE

<i>Clinical recommendation</i>	<i>Evidence rating</i>	<i>References</i>
Nursing home residents should be immunized with the 23-valent pneumococcal polysaccharide vaccine (Pneumovax).	A	5, 7
Nursing home residents should be immunized with the seasonal influenza vaccine.	C	9
Physicians should obtain chest radiography and pulse oximetry measurement in nursing home residents who have signs and symptoms of a pulmonary infection and who are candidates for treatment.	C	10
Antibiotics should be administered as soon as possible after diagnosing pneumonia in a nursing home patient.	C	20, 25, 26
Oral antibiotics can be used in patients with nursing home–acquired pneumonia who are treated in the nursing home.	C	21, 26, 42-45, 51
Patients with nursing home–acquired pneumonia should be treated for a total of five to eight days, unless they have <i>Pseudomonas aeruginosa</i> infection, are medically unstable, or demonstrate an inadequate clinical response to therapy.	C	3, 53-55
Patient and family wishes, goals of care, and availability of diagnostic tests and therapies should be considered when deciding whether or where to treat pneumonia in nursing home residents.	C	52, 59

A = consistent, good-quality patient-oriented evidence; B = inconsistent or limited-quality patient-oriented evidence; C = consensus, disease-oriented evidence, usual practice, expert opinion, or case series. For information about the SORT evidence rating system, go to <http://www.aafp.org/afpsort>.

and evaluated weekly for pneumonia. The diagnosis was made using a combination of clinical and radiographic findings, often confirmed by computed tomography. Patients immunized with the 23-valent pneumococcal polysaccharide vaccine were significantly less likely to be diagnosed with pneumococcal pneumonia or with pneumonia from all causes, as confirmed by blood or sputum cultures and urinary antigen tests.⁵

Similarly, a meta-analysis of 22 studies, including 15 randomized controlled trials (RCTs), found that the pneumococcal vaccine prevented invasive pneumococcal disease in adults.⁷

The recommendation by the Advisory Committee on Immunization Practices to administer the 13-valent pneumococcal conjugate vaccine in addition to the 23-valent pneumococcal polysaccharide vaccine is based on an RCT of 85,000 adults older than 65 years with no history of pneumococcal vaccination.⁶ The study was not specific to residents of nursing homes.

How Effective Is the Influenza Vaccine at Preventing Pneumonia?

Immunizing nursing home staff against influenza does not decrease the rate of lower respiratory tract infections, hospitalization, or death among residents. However, immunizing residents against influenza is effective at preventing influenza-associated pneumonia.

EVIDENCE SUMMARY

A Cochrane review of four RCTs and one cohort study found no benefit to immunizing health care workers against influenza for the prevention of influenza-associated pneumonia in nursing home residents older than 60 years.⁸ A cohort study of 2,351 patients in 83 long-term care facilities found that residents immunized against influenza were 43% less likely to develop influenza-associated pneumonia.⁹

Which Infectious Organisms Cause Pneumonia?

Streptococcus pneumoniae, gram-negative bacilli, Chlamydomphila pneumoniae, and both methicillin-resistant and methicillin-sensitive Staphylococcus aureus cause most cases of pneumonia in nursing homes. Less common infectious organisms include influenza A virus, respiratory syncytial virus, Haemophilus influenzae, Legionella species, Mycoplasma species, and Pseudomonas aeruginosa.

EVIDENCE SUMMARY

In most cases of nursing home–acquired pneumonia, the causative pathogen is unidentified. Estimates of the relative incidence of pneumonia from different infectious organisms rely mostly on studies that evaluated blood cultures and Gram stains of good-quality sputum specimens (more than 25 polymorphonuclear leukocytes and fewer

than 10 epithelial cells per low-power field). The estimates in these studies have wide confidence intervals.^{1,10,11}

Which Signs and Symptoms Suggest Infection?

*Nursing home residents may not show classic signs or symptoms of infection. Current IDSA practice guidelines state that a decline in functional status or a fever should prompt evaluation for infection in older nursing home residents.*¹⁰

EVIDENCE SUMMARY

A prospective cohort study from the 1980s found that among older adults residing in nursing homes, 77% of cases of new or worsening decline in functional status were associated with infection.¹² An observational study from the same era of older adults with acute illness (not limited to nursing home residents) identified fever in 95% of persons categorized as definitely having an infection.¹³

IDSA clinical practice guidelines from 2008 recommend investigating for infection in older nursing home residents who have fever (defined as a single oral temperature greater than 100°F [37.8°C], repeated oral temperatures greater than 99°F [37.2°C], rectal temperature greater than 99.5°F [37.5°C], or an increase in temperature greater than 2°F [1.1°C] above baseline), or who have a decline in functional status (defined as new or increasing confusion, incontinence, falling, deteriorating mobility, reduced food intake, or failure to cooperate with staff).¹⁰

How Does Pneumonia Present Clinically in Nursing Home Residents?

Older adults may not demonstrate classic symptoms of infection in general, and older adults in nursing homes who develop pneumonia may exhibit fewer classic signs and symptoms of respiratory disease than younger patients. However, most have at least one respiratory symptom.

EVIDENCE SUMMARY

A prospective cohort study of 1,474 nursing home residents with a radiographic diagnosis of pneumonia found that 80% of patients

had three or fewer symptoms of respiratory or systemic illness, but only 7.5% had no respiratory symptoms.¹⁴ The observation that older adults in nursing homes have fewer overt symptoms of pneumonia echoes findings from studies on the presentation of CAP in older adults.¹⁵⁻¹⁸

How Is Pneumonia Diagnosed?

Pulse oximetry measurement may aid in the diagnosis by identifying a pulmonary condition as the cause of infection. But, the diagnostic standard for pneumonia, including nursing home-acquired pneumonia, is chest radiography. Chest radiography should be performed in older nursing home residents with signs and symptoms of infection if they are candidates for treatment based on overall condition and life expectancy.

EVIDENCE SUMMARY

A small case-control study of 67 nursing home residents with acute infection found that oxygen saturation was lower in patients with pneumonia than in those with nonrespiratory infections.¹⁹ An oxygen saturation of less than 94% had a sensitivity of 80% and a specificity of 91% for pneumonia (positive likelihood ratio = 8.8; negative likelihood ratio = 0.22). IDSA guidelines recommend obtaining pulse oximetry measurements if patients are ill and show symptoms of infection, and if they are candidates for treatment based on their overall condition and life expectancy.¹⁰ The diagnosis is confirmed with chest radiography.

Which Studies Should Be Performed After Pneumonia Is Diagnosed?

*Nursing home residents who develop pneumonia and are not hospitalized do not routinely require additional diagnostic testing after confirmation with chest radiography. If patients are hospitalized with severe pneumonia, physicians may consider obtaining blood cultures and performing urinary antigen testing for *S. pneumoniae* and legionnaires' disease to tailor antibiotic therapy.^{3,20} For patients receiving mechanical ventilation, obtaining lower respiratory tract cultures via bronchoscopy to aid antibiotic selection may be considered.^{3,20}*

EVIDENCE SUMMARY

IDSA guidelines recommend considering pretreatment blood cultures for patients in an intensive care unit (ICU) who have cavitary infiltrates on pulmonary imaging, leukopenia, active alcohol abuse, chronic severe liver disease, asplenia, or pleural effusion.²¹ Blood cultures are not otherwise routinely necessary because of a lack of influence on care decisions.²⁰

A 2013 meta-analysis of 27 studies investigating *S. pneumoniae* urinary antigen testing in patients with CAP found a sensitivity of 74.0% and specificity of 97.2% (positive likelihood ratio = 26.4; negative likelihood ratio = 0.26), making it useful for narrowing the choice of antibiotic therapy.²² Evidence for the use of legionella urine antigen testing is less clear-cut; a 2009 meta-analysis found a sensitivity of 74% and a specificity of 99%, but many of the included studies were of poor quality.²³ Although that study was not limited to nursing homes, a 2010 retrospective study of 150 nursing home patients with pneumonia found pneumococcal and legionella antigens to be the most common identified etiologic markers. However, this finding was partly attributed to a diagnostic bias against identifying other less-common infectious organisms because of the difficulty obtaining quality sputum samples and the lack of blood cultures from patients without fever.²⁴

What Is the Recommended Timing for Antibiotic Administration?

Antibiotics should be administered as soon as possible after diagnosis of pneumonia, ideally within four to eight hours.

EVIDENCE SUMMARY

Although no studies have examined the timing of antibiotic administration for treating nursing home–acquired pneumonia, extrapolations from studies of older patients with CAP and hospital-acquired pneumonia suggest that antibiotics should be administered as soon as possible after diagnosis. A retrospective study of 13,771 patients 65 years and older with pneumonia found that antibiotic administration within four hours of arrival at the treating facility was associated

with decreased in-hospital mortality, 30-day mortality, and length of stay.²⁵ Another retrospective study of 14,069 patients 65 years and older found a decrease in 30-day mortality when antibiotics were given within eight hours of arrival at the emergency department.²⁰ The 2007 IDSA guidelines for health care–associated pneumonia recommend that the first dose of antibiotics be administered in the emergency department or as soon as possible.²⁶

Although a number of smaller studies have since replicated the finding of decreased length of stay with early antibiotic therapy, other studies have not shown an association with decreased mortality, length of stay, or time to clinical stability.^{27–32} These discrepancies may be due to differences in sample size, inclusion criteria, and measured outcomes.³³ Despite these differing results, the largest studies specific to patients 65 years and older support antibiotic administration as early as possible, ideally within four to eight hours.

Which Antibiotics Are Indicated for Nursing Home–Acquired Pneumonia?

Patients who are candidates for treatment should receive a respiratory fluoroquinolone alone, or an advanced macrolide plus a beta-lactam antibiotic. Doxycycline can be substituted for the macrolide if needed. A broader regimen should be considered in patients with severe illness, chronic wounds, foreign bodies in the airway, or risk factors for multidrug-resistant organisms. The broader-spectrum regimen should include one drug from each of the following three categories: an antipseudomonal cephalosporin, an antipseudomonal carbapenem, or a beta-lactam/beta-lactamase inhibitor; an antipseudomonal fluoroquinolone or aminoglycoside; and linezolid (Zyvox) or vancomycin.

EVIDENCE SUMMARY

There is little evidence to support one antibiotic regimen over another for treating nursing home–acquired pneumonia. The 2003 IDSA guidelines recommended a respiratory fluoroquinolone alone, or an advanced macrolide plus a beta-lactam when treating

pneumonia in nursing homes. The targeted organisms are similar to those in CAP: *S. pneumoniae*, *H. influenzae*, *Mycoplasma pneumoniae*, and *C. pneumoniae*.²¹

The 2005 IDSA guidelines on health care–acquired pneumonia and the 2007 guidelines on CAP suggest that nursing home–acquired pneumonia should be treated as a form of health care–acquired pneumonia.^{3,26} The focus is to cover multidrug-resistant organisms, such as *P. aeruginosa*, *Klebsiella pneumoniae*, *Acinetobacter* species, and methicillin-resistant *S. aureus*.³ However, these guidelines are based primarily on evidence from ventilator-associated pneumonia, which was then generalized to include nursing home–acquired pneumonia.³

Two studies support treating nursing home–acquired pneumonia as a form of health care–acquired pneumonia, but only in certain situations. In one study, the microbiologic etiologies of pneumonia were determined in 53% (n = 47) of nursing home patients older than 75 years with severe pneumonia who required mechanical ventilation in the ICU. In the subset of patients with nursing home–acquired pneumonia, the pathogens identified were *S. aureus* (29%), enteric gram-negative bacilli (15%), *S. pneumoniae* (9%), and *P. aeruginosa* (4%).³⁴ A second study looked at the microbiologic etiology of patients with nursing home–acquired pneumonia who were admitted to the hospital after their condition deteriorated or who did not improve after 72 hours of antibiotic treatment in the nursing home. The offending organism was identified in 46% (n = 52) of patients, with the most common being methicillin-resistant *S. aureus* (33%), enteric gram-negative bacilli (24%), and *P. aeruginosa* (14%).³⁵ These studies demonstrate that when standard therapy is ineffective, broader coverage to include multidrug-resistant organisms is indicated, similar to what is used for treatment of health care–acquired pneumonia.

Several other studies examining the microbiologic etiology of nonventilated nursing home–acquired pneumonia in hospitalized patients confirm that multidrug-resistant organisms are present in only a

minority of cases, and that *S. pneumoniae* and *C. pneumoniae* are the most common pathogens.^{36–38} This supports treating nursing home–acquired pneumonia as a form of CAP in most patients. Additionally, a retrospective study of 334 patients with nursing home–acquired pneumonia demonstrated similar time to clinical stability, in-hospital mortality, and 30-day mortality with either a CAP or a health care–acquired pneumonia treatment regimen.³⁹

Until additional data are available, current evidence suggests that a broader regimen covering multidrug-resistant pathogens should be reserved for specific populations, specifically patients with severe illness (e.g., mechanical ventilation, ICU admission, deterioration or lack of improvement after 72 hours), chronic wounds, foreign bodies in the airway, antibiotic use in the last 90 days, recent hospitalization, colonization with multidrug-resistant pathogens, very low functional status, or those who reside in a facility with a high prevalence of multidrug-resistant pathogens.^{24,34,35,40,41} This is consistent with the 2014 recommendations from NICE, which endorses treating uncomplicated nursing home–acquired pneumonia as a form of CAP.⁴

Should Nursing Home–Acquired Pneumonia Be Treated with Oral or IV Antibiotic Therapy?

Oral antibiotics can safely be used to treat pneumonia in nursing homes. Intramuscular or intravenous (IV) antibiotics may be used in certain circumstances, such as an inability to tolerate oral antibiotics. In a hospital setting where parenteral antibiotics are usually administered, oral antibiotics can be considered as initial therapy unless the patient is hemodynamically unstable or does not have a functioning gastrointestinal tract. In patients who receive IV antibiotics initially, oral antibiotics may be used once the patient is clinically stable if he or she has a functioning gastrointestinal tract and is able to tolerate oral medications.

EVIDENCE SUMMARY

Support for the use of oral antibiotics in nursing homes stems from several

retrospective cohort studies in which most patients with nursing home–acquired pneumonia were treated with oral antibiotics without a statistically significant increase in mortality rates.⁴²⁻⁴⁵

No studies have adequately examined the route of antibiotics for treating pneumonia in nursing home patients admitted to the hospital; therefore, recommendations for these patients are extrapolated from studies of CAP. For example, in one RCT of 85 patients admitted to the hospital with nonsevere CAP, those treated with oral antibiotics from the time of admission (followed by oral antibiotics once afebrile) had equal mortality rates and fewer adverse events compared with those treated initially with parenteral antibiotics. The same study demonstrated that of 103 patients admitted with severe CAP, those transitioned to oral antibiotics at 48 hours had no significant change in mortality, time to resolution, or treatment failure compared with those who remained on parenteral therapy. Patients who switched early to oral antibiotics had significantly fewer adverse events and greater cost savings compared with patients who remained on parenteral therapy.⁴⁶

Other CAP studies have shown similar cure and mortality rates, shorter hospital stays, and lower costs of care with an early switch to oral therapy.⁴⁷⁻⁵⁰ Transitions from IV to oral antibiotics for hospitalized patients are recommended by several guidelines.^{3,4,21,26,51}

What Is the Recommended Duration of Antibiotic Therapy?

Nursing home patients with pneumonia should be treated with antibiotics for five to eight days. The duration may need to be extended if there is a lack of clinical response, medical instability, or infection with P. aeruginosa.

EVIDENCE SUMMARY

There are no RCTs to guide the duration of treatment of pneumonia in nursing home patients. However, studies of CAP and ventilator-associated pneumonia suggest that in many cases, regimens can be shorter

than the previously suggested durations of seven to 14 days, or 10 to 14 days.^{51,52}

An RCT of 177 patients 65 years and older with CAP of varying severity were given levofloxacin (Levaquin) at a dosage of 750 mg per day for five days or 500 mg per day for 10 days. Clinical success rates were the same between the groups.⁵³ Similarly, an RCT of 401 patients with ventilator-associated pneumonia found that when patients received appropriate antibiotics initially, an eight-day regimen was as effective as a 15-day regimen, except in patients with nonfermenting gram-negative bacillus infections, such as with *Pseudomonas* and *Acinetobacter* organisms. For these patients, the pulmonary infection recurrence rate was higher with eight days of antibiotics.⁵⁴

Finding an exact number of treatment days that would be optimal for all patients is unlikely. Treatment should be based on comorbidities, the appropriateness of initial antibiotic choice, complications, and disease severity.⁵⁵

Which Patients Should Be Transferred to the Hospital?

The decision to hospitalize should first be based on patient goals, which ideally are known in advance of acute illness via an advance directive, a Physician Orders for Life-Sustaining Treatment form, a living will, or other form of documentation. Subsequently, the decision is based on the patient's clinical status, availability of diagnostic tests at the nursing home, and ability of the nursing home staff to provide appropriate therapies, which in some cases may be comfort care.

EVIDENCE SUMMARY

Hospitalization is not benign for older adults, with possible complications including functional decline, bedsores, delirium, and falls.⁵⁶ Several criteria have been proposed to determine whether patients with nursing home–acquired pneumonia should be hospitalized, and are primarily based on expert opinion, consensus, and retrospective cohort studies.

An RCT of 680 patients in 20 nursing homes used a clinical protocol that prompted

hospitalization if the patient did not meet set criteria: ability to eat and drink; pulse of 100 beats per minute or less; respiratory rate of 30 breaths per minute or less; systolic blood pressure of 90 mm Hg or greater (or a decrease of 20 mm Hg if baseline is less than 100 mm Hg); and oxygen saturation of 92% or greater (or 90% or greater in patients with chronic obstructive lung disease). This clinical pathway, which also provided criteria for diagnosis and treatment with oral and IV levofloxacin, led to decreased hospitalization and no difference in clinical outcomes, with a savings of \$1,016 per resident treated.⁵⁷ A prospective cohort study of 1,406 episodes of lower respiratory tract infections in nursing home patients found that hospitalization was not associated with a change in mortality rates and was more costly than treatment in the nursing home.⁵⁸

These studies do not suggest that all patients should be treated in the nursing home, but that most patients can be safely treated without transfer to the hospital. Ultimately, the decision to hospitalize is based on multiple factors, including patient wishes, clinical status, estimated mortality risk, and nursing home capabilities.^{52,59}

How Is a Patient's Prognosis Estimated?

The 30-day all-cause mortality rate for nursing home patients with pneumonia can be estimated with a clinical prediction rule called the SOAR score (which uses systolic blood pressure, oxygenation, age, and respiratory rate).

EVIDENCE SUMMARY

An analysis of prospectively collected data from 457 nursing home patients with pneumonia showed that the SOAR score is more accurate for predicting 30-day mortality and ICU admission rates than CURB, CURB-65, and CRB-65 scores (all of which use combinations of age, confusion, blood urea nitrogen level, respiratory rate, and blood pressure).⁶⁰

To calculate the SOAR score, one point is given for each of the following: systolic blood pressure less than 90 mm Hg, ratio of partial arterial oxygen pressure to fraction of inspired oxygen ($\text{PaO}_2/\text{FiO}_2$) less than 250,

age 65 years or older, and respiratory rate of 30 or more breaths per minute. A score of 2 or more is associated with a significantly higher 30-day mortality rate (33% mortality or greater vs. less than 8% mortality for a score of 1 or 0).⁶⁰

Data Sources: Literature and data sources for this article included the following databases: Cochrane, PubMed, Trip, DynaMed, National Guideline Clearinghouse, and Essential Evidence Plus. Keywords included long-term care facilities, assisted living facilities, nursing homes, rehabilitation centers, and pneumonia. The search included meta-analyses, randomized controlled trials, prospective studies, retrospective studies, and reviews. Search dates: April 2014 through June 2015.

The Authors

CATHERINE CASEY, MD, is an associate professor in the Department of Family Medicine at the University of Virginia School of Medicine in Charlottesville.

MELISSA J. FULLERTON, MD, is an assistant professor and the associate family medicine residency program director at the University of Virginia School of Medicine.

NICHOLAS SOMERVILLE, MD, MPH, is chief resident in the Department of Family Medicine at the University of Virginia School of Medicine.

Address correspondence to Catherine Casey, MD, University of Virginia, 375 Four Leaf Lane, Ste. 103, Charlottesville, VA 22903 (e-mail: cc5ds@virginia.edu). Reprints are not available from the authors.

REFERENCES

1. Muder RR. Pneumonia in residents of long-term care facilities: epidemiology, etiology, management, and prevention. *Am J Med.* 1998;105(4):319-330.
2. Loeb M, McGeer A, McArthur M, Walter S, Simor AE. Risk factors for pneumonia and other lower respiratory tract infections in elderly residents of long-term care facilities. *Arch Intern Med.* 1999;159(17):2058-2064.
3. American Thoracic Society; Infectious Diseases Society of America. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. *Am J Respir Crit Care Med.* 2005;171(4):388-416.
4. National Clinical Guideline Centre (UK). Pneumonia: diagnosis and management of community- and hospital-acquired pneumonia in adults. Clinical guideline 191. London: National Institute for Health and Care Excellence (UK); 2014.
5. Maruyama T, Taguchi O, Niederman MS, et al. Efficacy of 23-valent pneumococcal vaccine in preventing pneumonia and improving survival in nursing home residents: double blind, randomised and placebo controlled trial. *BMJ.* 2010;340:c1004.
6. Tomczyk S, et al.; Centers for Disease Control and Prevention (CDC). Use of 13-valent pneumococcal conjugate vaccine and 23-valent pneumococcal polysaccharide vaccine among adults aged ≥ 65 years:

- recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Morb Mortal Wkly Rep.* 2014;63(37):822-825.
7. Moberley S, et al. Vaccines for preventing pneumococcal infection in adults. *Cochrane Database Syst Rev.* 2013;(1):CD000422.
 8. Thomas RE, Jefferson T, Lasserson TJ. Influenza vaccination for healthcare workers who care for people aged 60 or older living in long-term care institutions. *Cochrane Database Syst Rev.* 2013;(7):CD005187.
 9. Monto AS, et al. Influenza vaccine effectiveness among elderly nursing home residents: a cohort study. *Am J Epidemiol.* 2001;154(2):155-160.
 10. High KP, Bradley SF, Gravenstein S, et al. Clinical practice guideline for the evaluation of fever and infection in older adult residents of long-term care facilities: 2008 update by the Infectious Diseases Society of America. *Clin Infect Dis.* 2009;48(2):149-171.
 11. Loeb M. Pneumonia in older persons. *Clin Infect Dis.* 2003;37(10):1335-1339.
 12. Berman P, Hogan DB, Fox RA. The atypical presentation of infection in old age. *Age Ageing.* 1987;16(4):201-207.
 13. McAlpine CH, Martin BJ, Lennox IM, Roberts MA. Pyrexia in infection in the elderly. *Age Ageing.* 1986;15(4):230-234.
 14. Mehr DR, et al. Clinical findings associated with radiographic pneumonia in nursing home residents. *J Fam Pract.* 2001;50(11):931-937.
 15. Marrie TJ, et al. Community-acquired pneumonia requiring hospitalization. Is it different in the elderly? *J Am Geriatr Soc.* 1985;33(10):671-680.
 16. Harper C, Newton P. Clinical aspects of pneumonia in the elderly veteran. *J Am Geriatr Soc.* 1989;37(9):867-872.
 17. Metlay JP, Schulz R, Li YH, et al. Influence of age on symptoms at presentation in patients with community-acquired pneumonia. *Arch Intern Med.* 1997;157(13):1453-1459.
 18. Zalacain R, Torres A, Celis R, et al.; Pneumonia in the elderly working group, Area de Tuberculosis e Infecciones Respiratorias. Community-acquired pneumonia in the elderly: Spanish multicentre study. *Eur Respir J.* 2003;21(2):294-302.
 19. Kaye KS, et al. Utility of pulse oximetry in diagnosing pneumonia in nursing home residents. *Am J Med Sci.* 2002;324(5):237-242.
 20. Meehan TP, et al. Quality of care, process, and outcomes in elderly patients with pneumonia. *JAMA.* 1997;278(23):2080-2084.
 21. Mandell LA, et al; Infectious Diseases Society of America. Update of practice guidelines for the management of community-acquired pneumonia in immunocompetent adults. *Clin Infect Dis.* 2003;37(11):1405-1433.
 22. Sinclair A, Xie X, Teltscher M, Dendukuri N. Systematic review and meta-analysis of a urine-based pneumococcal antigen test for diagnosis of community-acquired pneumonia caused by *Streptococcus pneumoniae*. *J Clin Microbiol.* 2013;51(7):2303-2310.
 23. Shimada T, et al. Systematic review and metaanalysis: urinary antigen tests for Legionellosis. *Chest.* 2009;136(6):1576-1585.
 24. Polverino E, Dambrava P, Cillóniz C, et al. Nursing home-acquired pneumonia: a 10 year single-centre experience [published correction appears in *Thorax.* 2010;65(9):844]. *Thorax.* 2010;65(4):354-359.
 25. Houck PM, et al. Timing of antibiotic administration and outcomes for Medicare patients hospitalized with community-acquired pneumonia. *Arch Intern Med.* 2004;164(6):637-644.
 26. Mandell LA, Wunderink RG, Anzueto A, et al. Infectious Diseases Society of America/American Thoracic Society consensus guidelines on the management of community-acquired pneumonia in adults. *Clin Infect Dis.* 2007;44(suppl 2):S27-S72.
 27. Benenson R, Magalski A, Cavanaugh S, Williams E. Effects of a pneumonia clinical pathway on time to antibiotic treatment, length of stay, and mortality. *Acad Emerg Med.* 1999;6(12):1243-1248.
 28. Battleman DS, Callahan M, Thaler HT. Rapid antibiotic delivery and appropriate antibiotic selection reduce length of hospital stay of patients with acute community-acquired pneumonia: link between quality of care and resource utilization. *Arch Intern Med.* 2002;162(6):682-688.
 29. Ziss DR, et al. Community-acquired pneumonia: compliance with Centers for Medicare and Medicaid Services, national guidelines, and factors associated with outcome. *South Med J.* 2003;96(10):949-959.
 30. Silber SH, Garrett C, Singh R, et al. Early administration of antibiotics does not shorten time to clinical stability in patients with moderate-to-severe community-acquired pneumonia. *Chest.* 2003;124(5):1798-1804.
 31. Marrie TJ, Wu L. Factors influencing in-hospital mortality in community-acquired pneumonia: a prospective study of patients not initially admitted to the ICU. *Chest.* 2005;127(4):1260-1270.
 32. Dedier J, et al. Processes of care, illness severity, and outcomes in the management of community-acquired pneumonia at academic hospitals. *Arch Intern Med.* 2001;161(17):2099-2104.
 33. Houck PM, Bratzler DW. Administration of first hospital antibiotics for community-acquired pneumonia: does timeliness affect outcomes? *Curr Opin Infect Dis.* 2005;18(2):151-156.
 34. El-Solh AA, et al. Etiology of severe pneumonia in the very elderly. *Am J Respir Crit Care Med.* 2001;163(3 pt 1):645-651.
 35. El-Solh AA, Aquilina AT, Dhillon RS, Ramadan F, Nowak P, Davies J. Impact of invasive strategy on management of antimicrobial treatment failure in institutionalized older people with severe pneumonia. *Am J Respir Crit Care Med.* 2002;166(8):1038-1043.
 36. Lim WS, Macfarlane JT. A prospective comparison of nursing home acquired pneumonia with community acquired pneumonia. *Eur Respir J.* 2001;18(2):362-368.
 37. Maruyama T, Niederman MS, Kobayashi T, et al. A prospective comparison of nursing home-acquired pneumonia with hospital-acquired pneumonia in non-intubated elderly. *Respir Med.* 2008;102(9):1287-1295.
 38. Maruyama T, Gabazza EC, Morser J, et al. Community-acquired pneumonia and nursing home-acquired pneumonia in the very elderly patients. *Respir Med.* 2010;104(4):584-592.
 39. El Solh AA, Akinnusi ME, Alfarah Z, Patel A. Effect of antibiotic guidelines on outcomes of hospitalized patients with nursing home-acquired pneumonia. *J Am Geriatr Soc.* 2009;57(6):1030-1035.
 40. El-Solh AA, Niederman MS, Drinka P. Management of pneumonia in the nursing home. *Chest.* 2010;138(6):1480-1485.

Pneumonia in Nursing Home Residents

41. El-Solh AA. Nursing home acquired pneumonia: approach to management. *Curr Opin Infect Dis.* 2011; 24(2):148-151.
42. Fried TR, Gillick MR, Lipsitz LA. Whether to transfer? Factors associated with hospitalization and outcome of elderly long-term care patients with pneumonia. *J Gen Intern Med.* 1995;10(5):246-250.
43. Naughton BJ, Mylotte JM, Tayara A. Outcome of nursing home-acquired pneumonia: derivation and application of a practical model to predict 30 day mortality. *J Am Geriatr Soc.* 2000;48(10):1292-1299.
44. Degelau J, et al. Effectiveness of oral antibiotic treatment in nursing home-acquired pneumonia. *J Am Geriatr Soc.* 1995;43(3):245-251.
45. Thompson RS, et al. Treatments and outcomes of nursing-home-acquired pneumonia. *J Am Board Fam Pract.* 1997;10(2):82-87.
46. Castro-Guardiola A, et al. Efficacy and safety of oral and early-switch therapy for community-acquired pneumonia: a randomized controlled trial. *Am J Med.* 2001; 111(5):367-374.
47. Oosterheert JJ, Bonten MJ, Schneider MM, et al. Effectiveness of early switch from intravenous to oral antibiotics in severe community acquired pneumonia: multicentre randomised trial. *BMJ.* 2006;333(7580):1193.
48. Omidvari K, et al. Early transition to oral antibiotic therapy for community-acquired pneumonia: duration of therapy, clinical outcomes, and cost analysis. *Respir Med.* 1998;92(8):1032-1039.
49. Ramirez JA, Vargas S, Ritter GW, et al. Early switch from intravenous to oral antibiotics and early hospital discharge: a prospective observational study of 200 consecutive patients with community-acquired pneumonia. *Arch Intern Med.* 1999;159(20):2449-2454.
50. Ramirez JA, Bordon J. Early switch from intravenous to oral antibiotics in hospitalized patients with bacteremic community-acquired *Streptococcus pneumoniae* pneumonia. *Arch Intern Med.* 2001;161(6):848-850.
51. Mandell LA, Marrie TJ, Grossman RF, Chow AW, Hyland RH. Canadian guidelines for the initial management of community-acquired pneumonia: an evidence-based update by the Canadian Infectious Diseases Society and the Canadian Thoracic Society. The Canadian Community-Acquired Pneumonia Working Group. *Clin Infect Dis.* 2000;31(2):383-421.
52. Hutt E, Kramer AM. Evidence-based guidelines for management of nursing home-acquired pneumonia. *J Fam Pract.* 2002;51(8):709-716.
53. Shorr AF, Zadeikis N, Xiang JX, Tennenberg AM, Wes Ely E. A multicenter, randomized, double-blind, retrospective comparison of 5- and 10-day regimens of levofloxacin in a subgroup of patients aged > or = 65 years with community-acquired pneumonia. *Clin Ther.* 2005;27(8):1251-1259.
54. Chastre J, Wolff M, Fagon JY, et al.; Pneuma Trial Group. Comparison of 8 vs 15 days of antibiotic therapy for ventilator-associated pneumonia in adults: a randomized trial. *JAMA.* 2003;290(19):2588-2598.
55. Niederman MS. Understanding the natural history of community-acquired pneumonia resolution: vital information for optimizing duration of therapy. *Clin Infect Dis.* 2004;39(12):1791-1793.
56. Creditor MC. Hazards of hospitalization of the elderly. *Ann Intern Med.* 1993;118(3):219-223.
57. Loeb M, Carusone SC, Goeree R, et al. Effect of a clinical pathway to reduce hospitalizations in nursing home residents with pneumonia: a randomized controlled trial. *JAMA.* 2006;295(21):2503-2510.
58. Kruse RL, et al. Does hospitalization impact survival after lower respiratory infection in nursing home residents? *Med Care.* 2004;42(9):860-870.
59. Bentley DW, et al; American Geriatrics Society; Gerontological Society of America, Clinical Medicine Section; Infectious Diseases Society of America; Society for Healthcare Epidemiology of America. Practice guideline for evaluation of fever and infection in long-term care facilities. *Clin Infect Dis.* 2000;31(3):640-653.
60. El-Solh AA, et al. Validity of severity scores in hospitalized patients with nursing home-acquired pneumonia. *Chest.* 2010;138(6):1371-1376.