

# Nursing Home-Acquired Pneumonia

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## Introduction

More than a century ago it was recognized that pneumonia was a disease that caused considerable morbidity and mortality, particularly in the elderly. In his classic textbook of internal medicine, Osier wrote, "Pneumonia is the special enemy of old age. In the aged, chances are against recovery. So fatal is it in this group that it has been called the natural enemy of the old man" (Osier, 1892). When he referred to pneumonia as the "friend of the aged" in a later edition of his textbook (Osier, 1898), he was commenting on the occurrence of pneumonia as a terminal illness among older persons with chronic, debilitating diseases. Even today lower respiratory tract infections (pneumonia and influenza) represent the fifth leading cause of death in the United States in those older than 65 years (Centers for Disease Control, 1990; National Center for Health Statistics, 1993). Aged individuals who are institutionalized in long-term care facilities are at particularly high risk for the development of pneumonia and represent a patient population with unique and challenging problems in the diagnosis, management, and prevention of these infections.

Approximately 5% of the population over the age of 65 years in the United States and Canada reside in a nursing home or other long-term care facility; more than one in five individuals over age 85 years live in a nursing home (Van Nostrand et al., 1979; Smith, 1985). This aged population is hetero-

geneous, and includes some relatively "healthy" and ambulatory individuals who require minimal nursing care, as well as those who are more severely impaired and totally dependent on their caregivers for assistance with the performance of activities of daily living. Infection accounts for approximately 27% of transfers from nursing homes to acute-care hospitals, and nearly half of these infections involve the respiratory tract (Irvine et al., 1984). Moreover, pneumonia has been the most frequent cause of death in nursing homes, occasionally unrecognized antemortem (Rossman et al., 1974; Nicolle et al., 1984; Gross et al., 1988a). Pneumonia, influenza, and other lower respiratory tract infections are also common causes of outbreaks in long-term care facilities, are associated with significant costs, and have an enormous impact on morbidity and mortality. This chapter reviews currently available data regarding the epidemiology, pathogenesis, etiology, diagnosis, treatment, and prevention of nursing home-acquired pneumonia. Although tuberculosis is also an important respiratory infection in long-term care facilities, a discussion of tuberculosis is beyond the scope of this review.

## Epidemiology, Risk Factors, and Outcome

Lower respiratory tract infections are generally recognized to be the second or third most common infections occurring in nursing home residents, accounting for up to 46% of all infections in long-term care facilities for the elderly (Garibaldi et al., 1981; Finnegan et al., 1985; Setia et al., 1985; Price et al., 1985; Scheckler & Peterson, 1986; Vlahov et al., 1987; Alvarez et al., 1988; Jacobson

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& Strausbaugh, 1990; Darnowski et al., 1991; Jackson et al., 1992; Beck-Sague et al., 1994; Lee et al., 1996). These infections are also among the most common causes of outbreaks occurring in chronic-care institutions (Jackson & Fierer, 1985; Li et al., 1996; Smith & Rusnak, 1997). Studies that have examined the incidence and prevalence of nursing home-acquired pneumonia are summarized in Tables 1 and 2, and indicate that approximately 2% to 5% of nursing home residents can be expected to develop such an infection annually, with an incidence ranging from 0.5 to 1.9 infections per 1000 resident-days. Some of the variability in the results found in these studies may be a reflection of the different types of long-term care facilities, various definitions of infection used, and variable methods of infection surveillance (McGeer et al., 1991).

Pneumonia has been identified as one of the most common reasons for transfer to a hospital from a nursing home (Irvine et al., 1984; Gordon et al., 1985). Approximately 30% of patients with nursing home-acquired pneumonia are transferred to a hospital (Degelau et al., 1995; Muder et al., 1996; Loeb et al., 1999) and in one study, pneumonia accounted for 12% of all hospital admissions among nursing home residents (Farber et al., 1984). The incidence of pneumonia requiring hospitalization is much higher in elderly nursing home residents (rates: 33–114 per 1000 population) than it is among non-institutionalized elderly subjects (rates: 1–7 per 1000 population) (Niederman & Fein, 1986; Marrie, 1990; Morris & Munasinghe, 1994).

**TABLE 2. Prevalence of Nursing Home-Acquired Pneumonia and Other Lower Respiratory Tract Infections**

Reference	Prevalence (%)	% of infections
Garibaldi et al., 1981	2.1	20
Setia et al., 1985	2.3	18
Price et al., 1985	1.1	44
Scheckler & Peterson, 1986	2.5	21

Several studies examining risk factors for the development of pneumonia in nursing home residents have identified the presence of underlying conditions such as chronic obstructive pulmonary disease, a tracheostomy, and a bedbound state as important determinants (Magaziner et al., 1991; Beck-Sague et al., 1993). Deteriorating health (odds ratio [OR], 4.95) and difficulty with oropharyngeal secretions (OR, 12.6) have also been associated with the acquisition of pneumonia in nursing home residents, suggesting the importance of aspiration (Harkness et al., 1990). Surrogate markers for aspiration were also found to be risk factors for pneumonia in a 3-year prospective study of nursing home-acquired pneumonia conducted by Loeb and coworkers (1999) involving 475 residents of five nursing homes. In a multivariate logistic regression analysis, older age (OR, 1.7 per 10-year interval;  $P = 0.01$ ), swallowing difficulty (OR, 1.9;  $P = 0.03$ ),

**TABLE 1. Incidence of Nursing Home-Acquired Pneumonia and Other Lower Respiratory Tract Infections**

Reference	Incidence	% of infections
Freeman et al., 1982	0.56 infections/year	
Farber et al., 1984	0.19/100 resident-days	
Nicolle et al., 1984	59/100 resident-years	
Scheckler & Peterson, 1986	1.9/100 resident-months	21
Marrie et al., 1986	33/1000 population	
Vlahov et al., 1987	1.0–1.9/1000 resident days	30–32
Berman et al., 1987	21/100 resident-years	
Alvarez et al., 1988	1.87/1000 resident-days	46
Hoffman et al., 1990	1.0/1000 resident-days	21
Harkness et al., 1990	0.73/1000 resident-days	
McDonald et al., 1992	1.46/1000 resident-days	
Degelau et al., 1995	0.5/1000 resident-days	
Loeb et al., 1999	0.7/1000 resident-days	

and inability to take oral medications (OR, 8.3;  $P = 0.02$ ) were found to be associated with the development of pneumonia. Receipt of influenza vaccine was protective (OR, 0.04;  $P = 0.01$ ).

In a meta-analysis of 127 studies of community-acquired pneumonia (CAP), among the highest mortality rates were found in the subgroup of 556 nursing home patients (Fine et al., 1996). Reported mortality rates for nursing home-acquired pneumonia have ranged from 6% to 40% (Nicolle et al., 1984; Finnegan et al., 1985; Marrie et al., 1986; Mehr et al., 1992; Beck-Sague et al., 1993; Drinka et al., 1994; Degelau et al., 1995; Muder et al., 1996; Marrie & Blanchard, 1997; Medina-Walpole & McCormick, 1998), and nursing home residence has been found to be an independent risk factor associated with increased mortality (Marrie et al., 1989; Marrie, 1990; Fine et al., 1997). Marrie and Blanchard (1997) found that the in-hospital mortality rate of 32% for nursing home-acquired pneumonia was significantly higher than the 14% mortality rate for age-matched controls with CAP. Mortality at 1 year following an episode of pneumonia was 58% in nursing home residents, similar to the 50% mortality in age-matched controls who were nursing home residents hospitalized without pneumonia, but significantly higher than the 30% 1-year mortality rate in age-matched individuals admitted to hospital with CAP ( $P < 0.01$ ). The major determinants of survival for the nursing home residents with pneumonia were a lack of complications during the hospital admission and the ability to perform activities of daily living independently. Impaired cognitive and/or functional status have been consistently identified as risk factors for both short-term and long-term mortality in elderly nursing home residents with pneumonia (Mehr et al., 1992; Salive et al., 1993; Fried et al., 1995; Muder et al., 1996; Medina-Walpole & McCormick, 1998). One study found that the use of oral broad-spectrum antibiotics (e.g., trimethoprim-sulfamethoxazole, ciprofloxacin, cefaclor, amoxicillin-clavulanate) as initial therapy was associated with an improved outcome (Fried et al., 1995).

### Host Defenses and Pathogenesis

With increasing age, several structural, physiological, and immunological changes occur that

may affect host defenses and responses to infection (Table 3).

Age-related immunological changes that have been described include a decreased ability to generate a cell-mediated immune response and a dysregulation of humoral immunity. Specific examples of altered immune responses in the elderly have included diminished lymphocyte responses to mitogens, decreased serum IgG and IgM antibody levels, diminished antibody responses to vaccines, and depressed in vitro phagocytic cell function (Phair et al., 1978; Amman et al., 1980; Goodwin et al., 1982; Simons & Reynolds, 1990; Scordamaglia et al., 1991). An altered systemic immune response may also be mirrored by changes in the lower respiratory tract of aged individuals. In a mouse model of bacterial pneumonia, normal aging of the animals was associated with changes in bronchoalveolar cellular responses to infectious agents such as *Staphylococcus aureus* and *Klebsiella pneumoniae*, although there was no apparent increase in susceptibility to pulmonary infection (Esposito & Pennington, 1983). Older mice had recruitment of larger numbers of neutrophils to the alveoli and bronchoalveolar spaces, and this was associated with more rapid pulmonary clearance of bacteria. In humans, changes in lymphocyte subsets in peripheral blood and alveolar secretions have been observed in older versus younger adults (Meyer et al., 1996). Other studies have found increased numbers of inflammatory cells and changes in surface immunoglobulins in lower respiratory tract secretions in aged individuals (Thompson et al., 1992). The role of immune senescence in predisposing individuals to the development of infection remains uncertain, although impaired cell-mediated immunity, as measured by defects in delayed hypersensitivity in the elderly, has been associated with an increased risk of tuberculosis and varicella-zoster.

Structural and physiologic pulmonary changes that occur with aging have been reviewed by Morris (1994) and will only briefly be summarized here. It is recognized that with age there is a loss of elastic recoil of the lung associated with changes in alveolar elastin and the development of panlobular emphysema (Knudson et al., 1977; Morris, 1994). There may also be increased bronchial wall compliance due to connective tissue degeneration, and the older individual may experience weakness of the diaphragmatic, chest wall, and abdominal muscles.

**TABLE 3. Factors Predisposing Elderly Nursing Home Residents to the Development of Pneumonia**

Factor	Effects
Immunosenescence	Impaired cell-mediated immunity Impaired humoral immune responses
Altered pulmonary defense mechanisms	Increased pulmonary compliance Decreased functional residual capacity Impaired mucociliary function and clearance of respiratory secretions Respiratory muscle weakness
Presence of underlying disease	
Chronic obstructive pulmonary disease	Reduced cough Impaired mucociliary clearance
Neurologic disease (cerebrovascular accident, dementia, Parkinson's disease)	Increased risk of aspiration Decreased clearance of respiratory secretions
Cardiac disease (congestive heart failure, pulmonary edema)	Impaired pulmonary alveolar macrophage function
Esophageal disease	Increased risk of aspiration
Diabetes mellitus	Impaired phagocytic cell function
Renal failure	Impaired humoral immunity and phagocytic cell function
Other factors	
Immobility	Impaired clearance of respiratory secretions
Malnutrition	Impaired immune function
Medications (e.g., sedatives, immunosuppressive agents)	Reduced cough or gag reflexes Increased risk of aspiration Impaired immune function

The net result of these changes is premature air trapping, larger residual volumes, and decreased functional residual capacity. Pulmonary function tests typically reveal mild airflow obstruction and reduced diffusing capacity (Crapo & Morris, 1981; Morris, 1994). With increasing age, there is also decreased efficiency in the clearance of respiratory secretions due to diminished gag and cough reflexes, decreased mucociliary function, and reduced tracheal mucus velocity (Fein et al., 1991).

Although alterations in pulmonary defenses and changes in systemic immune mechanisms with aging contribute to decreased physiologic reserve and thereby may increase the risk of respiratory infections, it is likely that the principal risk factor for pneumonia in the elderly is the presence of concomitant underlying disease. Conditions or diseases that occur with increased frequency in aged individuals that may alter host defenses and thereby increase the risk for development of pneumonia are summarized in Table 3. Many of these underlying conditions are associated with an impaired ability to clear respiratory secretions and/or an increased risk of aspiration.

The initial description of the pathogenesis of

pneumonia in elderly nursing home residents by Verghese and Berk (1983) is still believed to be an accurate reflection of the sequence of events in most patients. The elderly, debilitated resident of a long-term care facility is more likely to have oropharyngeal colonization with virulent organisms (e.g., aerobic gram-negative bacilli). Silent or inapparent aspiration of oropharyngeal secretions occurs frequently in the elderly, especially in the presence of underlying neurologic or esophageal diseases. Following aspiration, there may be an impaired ability for the host defenses to clear the inoculum of aspirated bacteria (due to diminished mucociliary clearance, decreased ability to generate an effective cough, or impaired pulmonary alveolar macrophage function). An antecedent viral respiratory tract infection may further compromise host defenses. The end result is the development of bacterial pneumonia.

It has been assumed that there is an association between swallowing dysfunction in the elderly and respiratory infection because of an increased risk of aspiration. The important role of aspiration in the development of nursing home-acquired pneumonia (Pick et al., 1996) is supported by the observation

that older patients with pneumonia are more likely to experience silent aspiration than are age-matched controls (Kikuchi et al., 1994) and by multivariate logistic regression analyses that have identified surrogate markers for aspiration (presence of swallowing disorders, difficulty with oral medications, and difficulty with oropharyngeal secretions) associated with the development of pneumonia in nursing home residents (Harkness et al., 1990; Loeb et al., 1999). In addition, Nakagawa and coworkers (1997) reported that the incidence of pneumonia was significantly higher in elderly nursing home residents with basal ganglia infarction and silent aspiration during sleep than in control residents in the facility.

Oropharyngeal colonization with aerobic gram-negative bacilli occurs frequently in the institutionalized elderly and is associated with requirements for greater assistance with the performance of activities of daily living (Valenti et al., 1978; Nicolle et al., 1986). Approximately one third of nursing home residents will be found to have oropharyngeal colonization with gram-negative bacilli, compared with less than 20% of those in the community (Valenti et al., 1978). Although such colonization may be transient (Irwin et al., 1982; Sveinbjörnsdóttir et al., 1991), the presence of gram-negative bacilli in the pharynx suggests either impaired bacterial clearance mechanisms or changes in mucosal receptors that allow altered bacterial adherence. Pharyngeal colonization with gram-negative bacilli among elderly nursing home residents has been associated with decreased functional status and increased mortality after 1 year of follow-up, but it is not clear that colonization leads to respiratory infection (Irwin et al., 1982; Nicolle et al., 1986). In addition, excess mortality in those who were colonized could be explained by the observation that colonization occurred more frequently in the more debilitated group (Nicolle et al., 1986). Therefore, the significance of oropharyngeal colonization with gram-negative bacilli in nursing home residents in predisposing them to the development of pneumonia or in influencing the microbial etiology of infection is uncertain.

## Microbial Etiology

There have been relatively few studies of nursing home-acquired pneumonia that include com-

prehensive investigations to determine the microbial etiology. It is difficult to obtain sputum or other respiratory tract specimens for culture in elderly nursing home residents, and diagnostic tests, especially for viral pathogens, are typically not ordered or available in long-term care facilities. Therefore, it is often impossible to identify the specific etiologic agent (Marrie et al., 1989; Venkatesan et al., 1990; Drinka et al., 1994; Janssens et al., 1996). Table 4 summarizes the results of selected studies that used extensive laboratory investigations and stringent diagnostic criteria in an attempt to establish the microbial etiology of nursing home-acquired pneumonia.

The most common sputum isolates in the institutionalized elderly with pneumonia have been *Streptococcus pneumoniae* and *Haemophilus influenzae*, although in several studies *S. aureus*, and a variety of Enterobacteriaceae have also been frequently identified. *S. pneumoniae* has been the most common blood culture isolate in patients with nursing home-acquired pneumonia (Marrie et al., 1989; Hirata-Dulas et al., 1991; Muder et al., 1992; Marrie & Blanchard, 1997). *S. aureus*, *H. influenzae*, and other aerobic gram-negative bacilli have also been associated with bacteremic pneumonia in these patients, but less frequently (Marrie et al., 1989; Muder et al., 1992; Marrie & Blanchard, 1997). Mixed bacterial infections, possibly related to aspiration, have been documented by some investigators (Bentley, 1984). Anaerobic pulmonary infection may occur in nursing home residents, although this generally occurs in patients with dental caries and poor oral hygiene, and is rarely found in those who are edentulous.

Some studies have suggested an increased incidence of pneumonia due to gram-negative bacilli in the elderly, particularly in those who reside in long-term care facilities (Garb et al., 1978; Ebright & Rytel, 1980; Bentley, 1984; Alvarez et al., 1988; Crossley & Thurn, 1989; Fein et al., 1991). Garb and colleagues (1978) found that patients with nursing home-acquired pneumonia were more likely to have gram-negative bacilli (especially *K. pneumoniae*) and *S. aureus* identified as etiologic agents than were elderly patients with CAP. However, sputum specimens in this study were often obtained after the start of antimicrobial therapy and were not assessed for adequacy prior to culture, making interpretation of culture results difficult. Although

TABLE 4. Microbial Etiology of Nursing Home-Acquired Pneumonia<sup>a</sup>

Pathogen identified	Study			
	Marrie et al., 1986 (74 episodes)	Marrie et al., 1989 (131 episodes)	Drinka et al., 1994 (56 episodes)	Loeb et al., 1999 (113 episodes)
<i>Streptococcus pneumoniae</i>	4%	7%	9%	2%
Other streptococci	3%	5%	2%	0
<i>Staphylococcus aureus</i>	4%	5%	2%	2%
<i>Haemophilus influenzae</i>	0	1%	7%	2%
<i>Moraxella catarrhalis</i>	0	0	5%	0
Other aerobic gram-negative bacilli	1%	8%	0	3%
<i>Legionella pneumophila</i>	1%	0	0	1%
<i>Chlamydia pneumoniae</i>	1%	0	0	2%
<i>Mycoplasma pneumoniae</i>	1%	1%	0	1%
Influenza virus	8%	11%	N/A	5%
Parainfluenza virus	1%	2%	N/A	5%
Cytomegalovirus	5%	4%	N/A	1%
Respiratory syncytial virus	0	0	N/A	1%
Other viruses	0	0	N/A	0
Aspiration	18%	15%	N/A	N/A
No etiology identified	64%	59%	75%	75%

<sup>a</sup>In prospective studies using stringent diagnostic criteria and extensive bacteriologic, virologic, and/or serologic evaluations. N/A, test not done

aerobic gram-negative bacilli may be recovered relatively frequently from sputum cultures of nursing home residents, these organisms are also more likely to colonize the oropharynx of the institutionalized elderly. In studies using more stringent diagnostic criteria, there has been no increased incidence of gram-negative bacilli causing pneumonia (Marrie et al., 1989; Hirata-Dulas et al., 1991; Phillips & Branaman-Phillips, 1993; Drinka et al., 1994; Marrie, 1994).

Viral lower respiratory tract infections are common in long-term care facilities, and many elderly nursing home residents with viral upper respiratory tract infection develop pneumonia (Nicholson et al., 1990; Wald et al., 1995b; Nicholson et al., 1997; Fiore et al., 1998). In the absence of an outbreak, laboratory investigations to identify a viral pathogen are rarely done in long-term care facilities. However, the viruses that have been identified most often in nursing home residents with lower respiratory tract infection are influenza A and B, parainfluenza viruses, and respiratory syncytial virus (RSV) (Morales et al., 1983; Falsey et al., 1990, 1992; Nicholson et al., 1990; Falsey, 1991; Loeb et al., 1999). Adenovirus and cytomegalovirus have

been detected less frequently. Although rhinoviruses and coronaviruses are typically associated with upper respiratory tract symptoms, these infections may also be complicated by lower respiratory tract involvement in the elderly (Wald et al., 1995b; Nicholson et al., 1997; Falsey et al., 1997).

*Legionella pneumophila*, *Chlamydia pneumoniae*, and *Mycoplasma pneumoniae* have only occasionally been identified as causes of pneumonia in long-term care facilities (Drinka et al., 1994; Janssens et al., 1996; Loeb et al., 1998). There have been a few reported outbreaks of infection due to *Legionella* species in nursing homes (Brennen et al., 1987; Mafasaki et al., 1992), but sporadic infection appears to occur infrequently. In a serosurvey of nursing home residents, only 2% had *Legionella* antibody titers > 1:64 (Storch et al., 1979), and studies that have attempted to detect *Legionella* in nursing home residents with pneumonia have rarely identified the organism (Marrie et al., 1989; Drinka et al., 1994; Janssens et al., 1996). Nursing home outbreaks of infection due to *C. pneumoniae* have been described (Troy et al., 1997), and a serological survey of nursing home residents has also detected evidence of occasional infection due to this organ-

ism (Orr et al., 1996). Studies that have looked for serologic evidence of *M. pneumoniae* respiratory infection in long-term care facilities for the elderly have rarely identified this organism, or have found evidence of mixed infection (Andrews et al., 1984; Arroyo et al., 1988; Orr et al., 1996; Loeb et al., 1999).

Outbreaks of respiratory tract infection in nursing homes occur commonly, and are most often due to viruses, especially influenza A and influenza B (Table 5). RSV is probably the most common non-influenza virus causing lower respiratory tract infection with serious morbidity in the elderly (Falsey et al., 1992). Similar to influenza, RSV infection in the elderly may also be associated with excess mortality (Fleming & Cross, 1993; Falsey et al., 1995). Numerous nursing home RSV outbreaks have been reported, associated with rates of pneumonia in up to 67% of patients and mortality rates as high as 50% (Garvie & Gray, 1980; Hart, 1984; Sorvillo et al., 1984; Mandal et al., 1985; Mai & Tamblyn, 1987; Agius et al., 1990; Osterweil & Norman, 1990). Nursing home outbreaks due to parainfluenza viruses have been described with rates of pneumonia ranging from 17% to 29% (Centers for Diseases Control, 1978; Public Health Laboratory Service, 1983; Glasgow et al., 1995), and pneumococcal pneumonia complicating antecedent parainfluenza virus infection has been reported (Fiore et al., 1998). Other pathogens associated with nursing home outbreaks of pneumonia have included *S. pneumoniae* (Quick et al., 1993; Kludt et al., 1997; Nuorti et al., 1998; Musher, 1998), *H. influenzae* (Patterson et al., 1988; Smith et al., 1988; Goetz et al., 1994), *C. pneumoniae* (Troy et al., 1997), and *Legionella* species (Brennen et al., 1987;

Mafasaki et al., 1992). Rhinoviruses and *Bordetella pertussis* have also been associated with outbreaks of lower respiratory tract infection in long-term care facilities (Addiss et al., 1991; Wald et al., 1995b). It is worth noting that outbreaks of respiratory infection in long-term care facilities are often mixed, with more than one pathogen circulating (Mathur et al., 1980; Gross et al., 1988b; Falsey, 1991; Fiore et al., 1998; Loeb et al., 2000).

## Specific Pathogens

### *Streptococcus pneumoniae*

*S. pneumoniae* is the most common identified cause of bacterial nursing home-acquired pneumonia. The rate of sporadic pneumococcal disease among nursing home residents (~ 352 per 100,000 population) is nearly 14 times higher than that among the noninstitutionalized elderly (~ 26 per 100,000) (Haglund et al., 1993). Mortality associated with bacteremic pneumococcal pneumonia is also higher in the elderly, with reported case-fatality rates as high as 35% to 44% (Finkelstein et al., 1983; Plouffe et al., 1996). In a retrospective review of adults with pneumococcal bacteremia, those over 65 years of age were more likely to be afebrile on admission to hospital, to have a delay in diagnosis, and to have a higher mortality rate (Finkelstein et al., 1983). It is likely that pneumococcal pneumonia is frequently unrecognized in nursing homes. The clinical features of pneumococcal pneumonia are indistinguishable from those associated with other respiratory pathogens (Marrie, 1992). Moreover, cultures are often not obtained in nursing homes, or they may fail to grow the organism due to delays in specimen processing. As a result, both sporadic cases and clusters of *S. pneumoniae* infection may be missed.

Several nursing home outbreaks of pneumococcal pneumonia in nursing homes have been reported (Quick et al., 1993; Yao et al., 1994; Kludt et al., 1997; Nuorti et al., 1998; Musher, 1998). In these long-term care facilities, attack rates of infection ranged from 7% to 15%, with significant rates of bacteremia and mortality (20%–71%). One of the outbreaks involved a multidrug-resistant strain of *S. pneumoniae*, serotype 23F (Nuorti et al., 1998). The

**TABLE 5. Microorganisms Associated with Outbreaks of Lower Respiratory Tract Infections in Nursing Homes**

Common	Uncommon
Influenza A	<i>Streptococcus pneumoniae</i>
Influenza B	<i>Haemophilus influenzae</i>
Parainfluenza virus	<i>Legionella pneumophila</i>
Respiratory syncytial virus	<i>Chlamydia pneumoniae</i>
Rhinovirus	<i>Mycobacterium tuberculosis</i>
	<i>Bordetella pertussis</i>

mode of transmission of *S. pneumoniae* in nursing homes is uncertain, but is possibly related to direct spread among colonized or infected residents in a closed environment and living close to one another. It is also possible that transmission originates from colonized staff. Of great significance is the observation that these outbreaks occurred in facilities with a highly susceptible and unvaccinated resident population; less than 12% of the nursing home residents had received the pneumococcal vaccine prior to the outbreak (Quick et al., 1993; Yao et al., 1994; Kludt et al., 1997; Nuorti et al., 1998; Musher, 1998). Further transmission of *S. pneumoniae* in the outbreaks was interrupted with the administration of prophylactic antibiotics and pneumococcal vaccine.

Although the overall antibody response to the currently available polyvalent polysaccharide pneumococcal vaccine in aged individuals is adequate, there may be a substantial number of more debilitated elderly with a suboptimal antibody response (Sankilampi et al., 1996; Rubins et al., 1998). In addition, some investigations have failed to demonstrate efficacy of the pneumococcal vaccine in the elderly (Fine et al., 1994; Örtqvist et al., 1998). However, most studies have confirmed that the vaccine is efficacious and cost-effective in reducing the incidence of invasive (bacteremic) pneumococcal disease in the aged (Sims et al., 1988; Shapiro et al., 1991; Butler et al., 1993; Sisk et al., 1997; Koivula et al., 1997). As *S. pneumoniae* is the most common cause of nursing home-acquired pneumonia and the potential for serious outbreaks of infection among unvaccinated nursing home residents has been demonstrated, it is recommended that long-term care facilities for the elderly offer pneumococcal vaccine to all eligible residents and to new residents on admission to the facility (Centers for Disease Control and Prevention, 1997). Unfortunately, despite these vaccine recommendations by the Advisory Committee on Immunization Practices, only a minority (~ 36%) of those over age 65 years in the United States have received the pneumococcal vaccine (Behavioral Risk Factor Surveillance System, 1997).

### **Influenza Virus**

Excess rates of mortality and hospitalization associated with influenza epidemics have been rec-

ognized for decades (Monto, 1987). The most severe impact has been reported among the institutionalized elderly or in those with various underlying medical conditions (Barker & Mullooly, 1980; Goodman et al., 1982; Arden et al., 1988; McBean et al., 1993; Morens & Rash, 1995), and both influenza A virus and influenza B virus have been implicated (Van Voris et al., 1982; Simor et al., 1988). More recently, it has also become evident that influenza virus infection occurring in nursing home residents may be associated with functional decline following recovery from infection (Barker et al., 1998). Influenza virus is known to interact with a variety of host defense mechanisms, increasing susceptibility to secondary bacterial superinfection and other complications (Couch, 1981; Scheiblaue et al., 1992). However, the elderly may be more susceptible to serious complications associated with influenza because of an age-related decrease in influenza A virus-specific cytotoxic T-lymphocyte activity (Powers, 1993).

Influenza is transmitted from person to person either by aerosol inhalation or by direct mucosal inoculation of the virus. Therefore, transmission may be facilitated in the closed environment of a long-term care facility, and sources of infection may include infected residents, staff, or visitors. Numerous nursing home outbreaks due to influenza are reported annually, with high attack rates and case-fatality rates (Patriarca et al., 1986; Brammer et al., 1997). Variables that have been identified as significant risk factors for the occurrence of influenza outbreaks in long-term care facilities include a larger facility size, a larger proportion of unvaccinated residents, and a larger proportion of residents susceptible to influenza virus infection (Patriarca et al., 1986). These three variables are interrelated and in a multivariate logistic regression analysis, the number of susceptible residents was found to be the most important factor predicting occurrence of an outbreak. These results suggest that high rates of immunization with the influenza vaccine would be protective.

There has been controversy regarding the efficacy of influenza vaccination in elderly nursing home residents, with reports of disappointingly low efficacy in long-term care facilities (Cartter et al., 1990). However, in a study of nursing homes experiencing outbreaks of infection due to influenza A, unvaccinated residents were more likely than those



vaccinated to become ill with a respiratory infection (risk ratio [RR], 2.6; 95% confidence interval [CI], 1.8–2.6), to be hospitalized (RR, 2.4; CI, 1.6–5.3), or to die (RR, 5.6; CI, 1.2–9.1) (Patriarca et al., 1985). In a meta-analysis of 20 studies assessing influenza vaccine efficacy in the elderly, pooled estimates of vaccine efficacy were 56% (CI, 35%–68%) for preventing respiratory illness, 53% (CI, 35%–66%) for preventing pneumonia, 50% (CI, 28%–65%) for preventing hospitalization, and 68% (CI, 56%–76%) for preventing death (Gross et al., 1995). In a randomized controlled study in long-term care facilities for the elderly in Scotland, there was a lower incidence of respiratory tract infections in facilities with vaccination programs for residents and staff, and decreased mortality in facilities with staff vaccination campaigns (Potter et al., 1997; Carman et al., 2000).

Recommended measures for the prevention and control of influenza in nursing homes include (1) annual influenza vaccination programs for residents and staff; (2) active surveillance for influenza-like illness with availability of rapid diagnostic tests to confirm the diagnosis of influenza virus infection; and (3) prompt implementation of infection control measures and chemoprophylaxis with amantadine hydrochloride or rimantadine hydrochloride in the setting of an outbreak (Gravenstein et al., 1992; Gomolin et al., 1995; Centers for Disease Control and Prevention, 1996). The value of using amantadine hydrochloride in controlling nursing home outbreaks due to influenza A virus has been demonstrated (Arden et al., 1988; Peters et al., 1989; Staynor et al., 1994; Monto et al., 1995), although there is an increased risk of neurologic adverse effects with this drug in the elderly (Stange et al., 1991; Guay, 1994). Newer neuraminidase inhibitors, such as zanamivir and oseltamivir, may also have an important role in the management of influenza in long-term care facilities.

## Clinical Features

It has long been recognized that the clinical manifestations of pneumonia in the elderly may be atypical or nonspecific compared with the features commonly seen in younger adults. Osier (1892) wrote more than a century ago that “in old age pneumonia may be latent, coming on without chill;

the cough and expectoration are slight, the physical signs ill-defined and changeable ...” These observations have since been confirmed by numerous investigators, although only a few studies have included control groups for comparison (Marrie et al., 1985, 1986; Marrie & Blanchard, 1997; Metlay et al., 1997).

A minority of elderly nursing home patients with pneumonia are able to cough or produce a purulent sputum sample, and physical signs of consolidation are infrequently found on examination (Bentley, 1984; Marrie et al., 1985). However, confusion, lethargy, or an altered mental state are often prominent features of pneumonia in the aged (Freeman et al., 1982; Bentley, 1984; Marrie et al., 1985; Starczewski et al., 1988; Venkatesan et al., 1990). Nursing home residents with pneumonia often present with “failure-to-thrive,” deterioration in functional status, or exacerbation of an underlying disease, such as congestive heart failure. Several studies have also emphasized the presence of tachypnea (respiratory rate > 25 breaths per minute) as an important clue to the diagnosis of pneumonia in the elderly, often preceding the appearance of other clinical findings (McFadden et al., 1982; Starczewski et al., 1988; Venkatesan et al., 1990).

A blunted or absent febrile response to infection has been noted in many older adults (Darowski et al., 1991; Castle et al., 1991, Norman & Yoshikawa, 1996). This may be related to a defect in thermoregulation with aging, lower basal temperature in the elderly, or technical difficulties in temperature measurement in older individuals. Pneumonia in the elderly, including bacteremic infection, may also present without fever (Finkelstein et al., 1983; Bentley, 1984; Starczewski et al., 1988; Venkatesan et al., 1990; Riquelme et al., 1997). A temperature less than 37.5°C on admission has been found to be associated with an increased risk of mortality (McAlpine et al., 1986; Ahkee et al., 1997).

Comparing older versus younger adults with CAP, Metlay and colleagues (1997) found that the elderly had a significantly lower prevalence of respiratory and constitutional symptoms such as fever, chills, cough, dyspnea, pleuritic chest pain, headache, and myalgias. In a linear regression analysis controlling for patient comorbidity and illness severity, older age remained associated with lower symptom scores. In a study of 74 elderly patients with nursing home-acquired pneumonia, Marrie

and coworkers (1986) found that only 68% were febrile, chills were present in 16%, cough in 62%, productive cough in 38%, and signs of pulmonary consolidation in 27%; 53% of patients presented with confusion. Although not statistically significant, the nursing home residents with pneumonia were less likely to have these respiratory symptoms or signs and more likely to be confused than were age-matched controls with CAP.

It is not possible to determine the etiologic agent responsible for respiratory tract infection based on the clinical presentation. The clinical features of pneumococcal pneumonia are indistinguishable from those of lower respiratory tract infection caused by other agents (Marrie, 1992), and it is not possible to reliably distinguish influenza virus infection from that due to RSV or other respiratory viruses by clinical criteria (Mathur et al., 1980; Falsey et al., 1992; Wald et al., 1995a; Nicholson et al., 1997).

The lack of classic signs or symptoms of pneumonia in the aged may either be due to altered physiological responses to infection, or because the older individual is unable to adequately express the presence of symptoms. Moreover, manifestations of pneumonia may be masked by the coexistence of other underlying diseases, such as chronic obstructive pulmonary disease or congestive heart failure. As a result, the diagnosis of pneumonia in the elderly nursing home resident is often delayed, and in one study was initially misdiagnosed in approximately 30% of patients (Riquelme et al., 1997).

## Diagnosis

The diagnosis of pneumonia in the elderly is challenging because of the atypical and nonspecific clinical manifestations. Patient assessment is further hampered because nursing home residents often have an ineffective cough and are unable to produce a purulent sputum sample. Laboratory testing and radiology facilities may not be readily available, and it may be difficult to obtain x-rays of good quality in confused or bedridden institutionalized patients. Nevertheless, recommended investigations for the evaluation of nursing home residents with suspected pneumonia include obtaining a chest x-ray and attempting to obtain sputum and

blood cultures. Although other laboratory tests, such as a complete blood count, serum electrolytes, measurements of renal and hepatic function, and determination of arterial oxygen saturation, are not useful for establishing the diagnosis of respiratory infection, they may provide information useful for subsequent management of the patient.

Chest radiography should be done to confirm the presence of a pulmonary infiltrate and to determine whether there are other complications or underlying diseases. The chest x-ray usually reveals an infiltrate at the time of presentation, although interpretation may be complicated by the presence of underlying conditions (e.g., chronic bullous or fibrotic changes, congestive heart failure, or malignancy). "Classic" changes of lobar consolidation may or may not be present, and it is hazardous to make an etiologic diagnosis based on the radiographic appearance (Andrews et al., 1984; Fein, 1994). It has been found that radiographic progression of disease is more likely to occur in older adults hospitalized with pneumonia (in 48% of those over age 65 years), than in younger adults (11% in those less than 65 years of age;  $P < 0.001$ ) (Marrie et al., 1985). Slower resolution of radiographic changes in the elderly recovering from pneumonia has also been documented (British Thoracic Society, 1987; Woodhead, 1994).

Cultures of lower respiratory tract secretions are generally used to determine the microbial etiology of pulmonary infection. However, only a minority of acutely ill nursing home residents are able to provide an adequate sputum sample for Gram stain examination and culture (Marrie et al., 1986; Fein, 1994; Drinka et al., 1994). Interpretation of sputum culture results is further complicated by the possibility of contamination of the specimen with oropharyngeal bacterial flora. Fastidious organisms such as *S. pneumoniae* may fail to grow because of delays in transporting the specimen to the laboratory for processing.

Blood cultures should be obtained in any patient with nursing home-acquired pneumonia who is sick enough to require hospital admission. Infections of the lower respiratory tract are among the most common sources of bacteremia in long-term care facility residents (Windsor, 1983; Setia et al., 1984; Muder et al., 1992), although blood cultures are positive in only about 4% to 8% of patients with

nursing home-acquired pneumonia (Marrie et al., 1986; Peterson et al., 1988; Hirata-Dulas et al., 1991; Phillips & Branaman-Phillips, 1993; Marrie & Blanchard, 1997).

Respiratory viral infection may be confirmed by virus isolation, detection of viral antigens, or serological tests. Such testing may be particularly important for the early recognition of outbreaks of respiratory infection in long-term care facilities. In these circumstances, viral antigens in nasopharyngeal swabs may be detected by immunofluorescence (DFA) or enzyme immunoassay (EIA) using one of several commercially available test kits. These tests can be done in a few hours, thereby providing same-day results. Both DFA and EIA for the rapid detection of influenza viral antigens have been found to have sensitivities of 87% to 100% and specificities greater than 92% (Waner et al., 1991; Leonardi et al., 1994). Leonardi and colleagues (1994) found that the rapid diagnosis of influenza using direct antigen detection tests and subsequent implementation of appropriate interventions could prevent significant morbidity.

Acute and convalescent serology or other diagnostic tests may be required for the identification of other potential respiratory pathogens, such as *L. pneumophila*, *C. pneumoniae*, or respiratory viruses. Serologic testing is of greater value for subsequently confirming a diagnosis than it is for the clinical management of individual patients.

## Treatment

The vast majority of patients with nursing home-acquired pneumonia are treated empirically without knowledge of the specific etiologic agent. The treating physician must initially consider at least two questions: (1) Should the nursing home resident be hospitalized, or can he or she be safely treated in the long-term care facility? (2) What empiric antimicrobial agent(s) should be used, and should the drug(s) be administered orally or parenterally?

Advantages of treating the patient with pneumonia in the nursing home include decreased costs of care and avoidance of nosocomial complications such as precipitation of acute confusion or delirium, immobilization, and development of decubitus ul-

cers. Several retrospective studies have suggested that many nursing home residents with pneumonia can be safely and effectively treated in the facility using oral antimicrobial agents and without being transferred to a hospital (Degelau et al., 1995; Fried et al., 1995; Thompson et al., 1997; Fried et al., 1997). These studies found that there was no increased mortality in residents with pneumonia who were initially treated in the nursing home, compared with residents transferred to an acute-care hospital for their treatment. In the one study that assessed short-term functional outcomes, no significant differences were detected in residents with pneumonia treated with and without hospital transfer (Fried et al., 1997). Treatment failure for those managed in the nursing homes was associated with tachypnea (Degelau et al., 1995; Fried et al., 1995; Thompson et al., 1997), the presence of abnormal vital signs, and the requirement for feeding assistance or a mechanically altered diet (Degelau et al., 1995).

These studies suggest that the majority of patients with nursing home-acquired pneumonia can be treated safely in the facility with oral antibiotics. How to select patients for hospital transfer remains uncertain. In general, it would appear that those who are clinically stable (i.e., stable vital signs and adequate oxygenation) and who are able to tolerate oral medications would be suitable candidates for therapy within the nursing home. However, other factors to consider include the availability of any required supportive therapy or monitoring and appropriate goals of therapy for the individual.

There have been only a few prospective, randomized, controlled trials comparing the efficacy of different antimicrobial therapies for the treatment of nursing home-acquired pneumonia (Table 6; Peterson et al., 1988; Hirata-Dulas et al., 1991; Phillips & Branaman-Phillips, 1993; Nicolle et al., 1996b). These studies generally involved small numbers of subjects and primarily included those who were transferred to an acute-care hospital for the treatment of their infection. Therefore, only scanty data are available for the development of evidence-based treatment guidelines. In fact, the recently published guidelines from the Infectious Diseases Society of America (Bartlett et al., 2000) for the management of community-acquired pneumonia in adults did not address the issue of nursing

**TABLE 6. Randomized, Controlled Trials of Antimicrobial Therapy for Nursing Home-Acquired Pneumonia**

Study	Most common bacterial isolates (no.)	Antimicrobial therapy	Number treated	% efficacy ( <i>P</i> value)
Peterson et al., 1988	<i>S. pneumoniae</i> (7)	Cefamandole (IM)	30	70
	<i>H. influenzae</i> (7)	Ciprofloxacin (PO)	30	77 ( <i>P</i> > 0.05)
	<i>E. coli</i> (4)			
Hirata-Dulas et al., 1991	<i>S. pneumoniae</i> (7)	Ceftriaxone (IV/IM)	26	54
	<i>H. influenzae</i> (5)	Ciprofloxacin (IV/PO)	24	50 ( <i>P</i> > 0.05)
	<i>S. aureus</i> (2)			
Phillips & Branaman-Phillips, 1993	<i>S. pneumoniae</i> (31)		54	94
	<i>H. influenzae</i> (20)	Ceftriaxone (IM)	50	90 ( <i>P</i> > 0.05)
	<i>S. aureus</i> (11)	Cefoperazone (IM)		
Nicolle et al., 1996b	<i>S. pneumoniae</i> (4)	Ampicillin (IV)	20	70
		Ceftriaxone (IV)	17	93 ( <i>P</i> = 0.07)

IM, intramuscular; IV, intravenous; PO, orally.

home-acquired pneumonia at all. Treatment guidelines adopted by the American Thoracic Society (1993) acknowledged that older age was an important prognostic factor, but did not categorize nursing home-acquired pneumonias separately because of a consensus that the place of residence was less important than the presence of coexisting disease and advanced age. Only the Canadian consensus guidelines for the treatment of community-acquired pneumonia considered specific therapy for nursing home residents (Mandell et al., 1993).

Recommended empiric therapy for pneumonia in long-term care facilities has generally included broad-spectrum coverage of *S. pneumoniae*, *H. influenzae*, and aerobic gram-negative bacilli (Yoshikawa, 1991; Saltiel & Weingarten, 1993; Mandell et al., 1993; Mylotte et al., 1994; Marrie & Slayter, 1996). Published consensus treatment guidelines that address nursing home-acquired pneumonia are summarized in Table 7. The Canadian treatment guidelines (Mandell et al., 1993) recommend the use of broad-spectrum agents that possess activity against aerobic gram-negative bacilli. In contrast, the Position Paper of the Long-Term-Care Committee of the Society for Healthcare Epidemiology of America (Nicolle et al., 1996a) indicates that “quinolones, broad-spectrum cephalosporins or penicillins, and aminoglycosides should not be prescribed as agents of first choice” for the empiric treatment of nursing home-acquired pneumonia.

Since the publication of these recommendations,

newer fluoroquinolones such as levofloxacin have become available. These agents are available as oral formulations and have enhanced in vitro activity against *S. pneumoniae* and other respiratory pathogens. Several features of these drugs would appear to make them suitable for the treatment of lower respiratory tract infections in long-term care facilities, but the role of the newer quinolones in the management of nursing home-acquired pneumonia will need to be defined.

## Infection Control and Prevention

Unfortunately, there are currently few strategies for the prevention of nursing home-acquired pneumonia that are of proven benefit. Pneumococcal infection and influenza are each able to cause considerable morbidity and mortality in long-term care facilities. Even though currently available pneumococcal and influenza vaccines may have suboptimal efficacies in the elderly, the impact of these infections may be substantially reduced by immunization. Therefore, nursing homes should offer the pneumococcal vaccine to all eligible residents and to new residents on admission to the facility (Centers for Disease Control and Prevention, 1997). In addition, each resident should receive the influenza vaccine annually unless medically contraindicated (Centers for Disease Control and Prevention, 1996). Staff should also be offered

**TABLE 7. Published Consensus Guidelines  
for the Treatment of Nursing Home-Acquired Pneumonia**

Canadian Community-Acquired Pneumonia Consensus Conference Group (Mandell et al., 1993)	Society for Healthcare Epidemiology of America Long-Term-Care Committee Position Paper (Nicolle et al., 1996a)
Treatment options in the nursing home	Oral therapy
Second-generation cephalosporin $\pm$ macrolide	Trimethoprim-sulfamethoxazole
Trimethoprim-sulfamethoxazole $\pm$ macrolide	Amoxicillin
Ceftriaxone $\pm$ macrolide	Cefuroxime-axetil
Amoxicillin-clavulanate	Macrolide
Penicillin + ciprofloxacin	Amoxicillin-clavulanate
Clindamycin + ciprofloxacin	Parenteral therapy
Treatment options for hospitalized patients	Ceftriaxone
Second/third-generation cephalosporin $\pm$ macrolide	
Trimethoprim-sulfamethoxazole $\pm$ macrolide	

and encouraged to receive annual influenza vaccination. Despite recommendations for vaccination of high-risk and institutionalized elderly subjects, there is considerable room for improvement in the implementation of institutional policies for influenza and pneumococcal immunization programs in long-term care facilities (McArthur et al., 1995; Behavioral Risk Factor Surveillance System, 1997).

Every long-term care facility should have an effective infection control program in order to identify potentially preventable sporadic infections and for early detection of outbreaks of infection (Nicolle & Garibaldi, 1995; Smith & Rusnak, 1997). Staff should be familiar with the basic principles of infection transmission and infection control; the importance of basic hygiene and handwashing should be emphasized. There should be policies for tracheostomy care and for the appropriate care and cleaning of respiratory therapy equipment. Residents should be screened for tuberculosis on admission and staff should be periodically monitored with tuberculin skin tests. Policies regarding visitors should be developed to reduce the risk of introducing community-acquired respiratory infections (e.g., influenza) into the facility. Infection surveillance should be conducted for early detection of outbreaks, and there should be policies for rapid response to outbreaks when they occur. Provisions for rapid influenza diagnostic testing should be in place before the onset of influenza season each year, including prior arrangements with the local laboratory and ensuring the on-site availability of appropriate specimen swabs and supplies. Specific

recommendations in the presence of an influenza A outbreak include the following: symptomatic residents should be isolated or grouped together; symptomatic staff should be removed from patient care activities; ill visitors should refrain from visiting the facility; and chemoprophylaxis with amantadine hydrochloride or rimantadine hydrochloride (or possibly a neuraminidase inhibitor) should be provided (Gomolin et al., 1995).

## Summary and Future Studies

Elderly residents of long-term care facilities who develop pneumonia experience significant morbidity and mortality. These infections are also associated with substantial costs, especially those related to hospitalization. Much of the currently available data regarding these infections is based on relatively small, retrospective studies or on investigations that involved a subset of patients who were transferred to an acute-care hospital. There is clearly a need to develop improved strategies for the diagnosis, management, and prevention of nursing home-acquired pneumonia. Examples of specific research questions regarding respiratory tract infections in long-term care facilities that need to be addressed are listed in Table 8.

Clinicians caring for the elderly are challenged by difficulties in establishing the diagnosis and determining the microbial etiology of pneumonia in nursing homes. Problems arise because these patients tend to present with nonspecific clinical fea-

**TABLE 8. Questions to Be Addressed in Order to Improve the Management and Prevention of Nursing Home-Acquired Pneumonia**

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- What modifiable risk factors can identify nursing home residents at high risk for the development of pneumonia?
- Are there specific interventions aimed at reducing these risks that are effective in preventing the development of pneumonia (e.g., feeding practices; patient positioning; use of oral anti-infective mouthwashes)?
- What is the role of oropharyngeal colonization with aerobic gram-negative bacilli on the microbial etiology of nursing-home acquired pneumonia?
- Is empiric therapy using antimicrobial agents with broad-spectrum activity against gram-negative aerobes (e.g., ceftriaxone, fluoroquinolones) more efficacious than treatment with antibiotics having a narrower spectrum of activity (e.g., amoxicillin; cephalexin; trimethoprim-sulfamethoxazole; macrolides)?
- Is it possible to identify which residents with pneumonia can be safely and effectively treated in the nursing home, and which ones should be more appropriately hospitalized?
- What are the most appropriate infection surveillance methods for lower respiratory tract infections in long-term care facilities?
- How can immunization rates with pneumococcal and influenza vaccines be improved in nursing homes?
- What is the best way to improve staff influenza vaccination rates in long-term care facilities?
- What infection control interventions are most effective during nursing home outbreaks due to influenza or other respiratory viruses?
- 

tures, often have coexistent underlying diseases, and are typically unable to provide appropriate diagnostic specimens. Moreover, on-site laboratory and x-ray facilities are infrequently available, and there may be difficulties in the interpretation of culture results. Therefore, carefully designed prospective studies are needed for improved identification of patients at risk and to better define the microbial etiology of nursing home-acquired pneumonia. Such information is critical in order to determine the most effective empiric treatment. It is also important to be able to identify which residents with pneumonia may be safely treated in the nursing home and which ones should be transferred to a hospital for management. In order to design effective preventive measures, modifiable risk factors for nursing home-acquired pneumonia must be defined. The effectiveness of interventions, such as those aimed at preventing aspiration, should be determined. Similarly, the effectiveness of infection

control measures recommended for the management of outbreaks of respiratory infections needs to be evaluated.

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