

Infectious Disease Outbreaks in Nursing Homes: An Unappreciated Hazard for Frail Elderly Persons

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The common occurrence and dire consequences of infectious disease outbreaks in nursing homes often go unrecognized and unappreciated. Nevertheless, these facilities provide an ideal environment for acquisition and spread of infection: susceptible residents who share sources of air, food, water, and health care in a crowded institutional setting. Moreover, visitors, staff, and residents constantly come and go, bringing in pathogens from both the hospital and the community. Outbreaks of respiratory and gastrointestinal infection predominate in this setting, but outbreaks of skin and soft-tissue infection and infections caused by antimicrobial-resistant bacteria also occur with some frequency.

Outbreaks of infectious diseases can decimate resident populations in nursing home facilities. For example, Morens and Rash [1] reported an outbreak of influenza A infection in a 37-bed unit of a 5-ward nursing home in Honolulu, Hawaii, that affected 28% of exposed residents, even though 92% of residents had received influenza vaccine prior to the outbreak. Moreover, 6 (55%) of 11 infected residents died of their illness. Similarly, Auerbach and colleagues [2] reported an outbreak of *Streptococcus pyogenes* infection in a North Carolina nursing home that affected 16 (20%) of 80 residents and 3 (7%) of 45 staff. Four (36%) of 11 residents with invasive disease died of their infections.

As these dramatic reports indicate, nursing homes provide the requisite ingredients for outbreaks of infectious diseases [3]. As a rule, elderly nursing home residents have multiple chronic diseases and functional impairments that predispose them to infection. Residents share sources of air, food, water, and medical care, which facilitates both the introduction and subsequent transmission of certain infectious agents among vulnerable residents. Prolonged lengths of stay, limited capacities for diagnosis, and ineffectual infection-control programs

often allow outbreaks to propagate and persist for many months. Transfer of infected or colonized residents, which is a common occurrence [4], may export outbreaks to other facilities, including hospitals and medical centers.

The frequency of outbreaks in nursing homes is not known, but a variety of data suggest that they are common. Outbreak reports constitute one-third of the infectious disease literature emanating from nursing homes [5]. The Centers for Disease Control and Prevention (CDC) responds with some regularity to requests for assistance in managing outbreaks in this setting [6, 7]. Publications from state health departments also periodically attest to the occurrence of outbreaks in nursing homes [8, 9]. Finally, surveillance studies of nursing homes have occasionally detected clusters of various infections [10].

Nevertheless, as these data sources suggest, information about outbreaks of infection in nursing homes is widely dispersed. For this reason, many physicians may fail to appreciate the frequency and severity of nursing home outbreaks or their potential impact on other health care facilities. Accordingly, this minireview seeks to raise awareness about this aspect of infectious diseases in nursing homes by consolidating information about the occurrence and types of outbreaks.

OUTBREAKS OF RESPIRATORY TRACT INFECTION

Outbreaks of respiratory tract infection in nursing homes derive from residents (e.g., those with reactivation tuberculosis) and

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nonresidents, staff, or visitors with acute respiratory infection (table 1). Once introduced into the nursing home, respiratory tract pathogens often disseminate rapidly among residents and staff. Depending on the infectious agent, they may spread via large respiratory droplets, direct or indirect contact, or airborne droplet nuclei.

Outbreaks of respiratory tract infection occur frequently throughout the year in nursing homes. Data from the New York State Department of Health (Albany) for 1992 identified 164 outbreaks of respiratory tract infection, which accounted for 48% of all outbreaks reported [8]. In a 3-year study involving active surveillance for respiratory outbreaks in 5 Canadian nursing homes, Loeb and colleagues [11] identified 16 outbreaks prospectively and 30 outbreaks retrospectively. Outbreaks occurred during 9% of all resident-care days and accounted for 43% of all respiratory tract infections during the study period. The 16 outbreaks identified prospectively involved 480 of 1313 residents and occurred more frequently during the winter months. Attack rates ranged from 2% to 25%, and the overall case-fatality rate was 8%. Pathogens isolated from infected patients included influenza virus (influenza A virus in 5 outbreaks and influenza B virus in 2 outbreaks), parainfluenza virus (in 13 outbreaks), respiratory syncytial virus (RSV; in 2 outbreaks), *Chlamydia pneumoniae* (in 1 outbreak), and *Legionella saintheleni* (in 1 outbreak). Cultures yielded multiple pathogens in 6 outbreaks, and no pathogens were recovered from residents in 3 of the 16 outbreaks.

A majority of the 30 outbreaks identified from a retrospective review of recorded symptoms occurred during summer months and affected fewer residents than in outbreaks identified prospectively; nevertheless, a total of 388 cases were detected [11]. Cultures of respiratory secretion samples obtained from infected residents yielded viral pathogens for 13 of the 30 outbreaks: parainfluenza 3 in 11 outbreaks, RSV in 1 outbreak, and both parainfluenza 3 and RSV in 1 outbreak. In 1 other outbreak, 2 residents had 4-fold increases in the level of antibodies to *C. pneumoniae*.

Influenza viruses. Outbreaks of influenza occur with regularity in nursing homes and often affect multiple facilities in the same region. For example, in a 7-county survey conducted prospectively in lower Michigan during the 1989–1990 influenza season, influenza outbreaks were identified in 17 facilities (38% of those studied) [12]. Similarly, during the 1997–1998 influenza season, 43 adult residential facilities in Virginia, including 32 nursing homes, reported outbreaks, which involved a total of 788 residents [9].

In the medical literature, influenza ranks among the most commonly reported causes of outbreaks of infectious disease in nursing homes. A review for the period 1988–1998 identified 16 reports [13]. These outbreaks involved >1000 residents in at least 20 facilities. Outbreaks caused by influenza A virus

Table 1. Etiologic agents of respiratory disease outbreaks in nursing homes.

Viruses
Influenza A virus
Influenza B virus
Parainfluenza virus
Respiratory syncytial virus
Rhinoviruses
Bacteria
<i>Streptococcus pneumoniae</i>
<i>Chlamydia pneumoniae</i>
<i>Chlamydia psittaci</i>
<i>Mycobacterium tuberculosis</i>
<i>Legionella</i> species
<i>Haemophilus influenzae</i>
<i>Bordetella pertussis</i>

occurred most commonly, but outbreaks caused by influenza B virus also were reported. Attack rates generally ranged from 20% to 30% but were >40% in 2 reported outbreaks during the 10-year period.

Although more common in the winter months, influenza outbreaks in nursing homes can occur at any time during the year. They may also occur despite liberal use of influenza vaccine, reflecting both the antigenic limitations of the vaccine for a given season and the diminished immunological responses of frail elderly persons. Vaccination rates of >80% of residents at a given institution have correlated with decreased risk of an outbreak [14]. However, as the authors learned recently in their own facility (the Nursing Skilled Care Unit, Portland VA Medical Center, Portland, OR), outbreaks can occur even when resident vaccination rates are >90%. Staff vaccination rates appear to be more important than are resident vaccination rates in reducing mortality from influenza [15]. They may also play a role in preventing institutional outbreaks. Even in nursing homes with high vaccination rates, some outbreaks fail to resolve without facility-wide chemoprophylaxis with an antiviral agent (e.g., amantadine, rimantadine, or oseltamivir). The Society for Healthcare Epidemiology of America has published guidelines for prevention of influenza in long-term care facilities (LTCFs) that address the management of outbreaks [13].

Mycobacterium tuberculosis. Tuberculosis poses a perennial threat to nursing home residents. The higher frequency of prior infection with *M. tuberculosis* in the elderly population, coupled with the immunological decline characteristic of elderly persons, foments higher rates of tuberculosis in the nursing home setting. A survey of 15,379 reported cases in 29 states indicated that the incidence of tuberculosis among nursing home residents was 39.2 cases per 100,000 population, compared with 21.5 cases per 100,000 population among elderly

Table 2. Etiologic agents of outbreaks of gastrointestinal infection in nursing homes.

Viruses
Caliciviridae ^a
Rotaviruses
Adenoviruses
Astroviruses
Bacteria
<i>Salmonella</i> species
<i>Shigella</i> species
<i>Staphylococcus aureus</i>
<i>Clostridium perfringens</i>
<i>Clostridium difficile</i>
<i>Escherichia coli</i> 0157:H7
<i>Aeromonas hydrophila</i>
<i>Campylobacter jejuni</i>
<i>Bacillus cereus</i>
Parasites
<i>Entamoeba histolytica</i>
<i>Giardia lamblia</i>
<i>Cryptosporidium parvum</i>

^a A family of small, round-structured viruses that includes Norwalk virus, Snow Mountain virus, and many others.

persons living in the community [16]. Residents who develop reactivated disease and residents who develop active tuberculosis after exposure to those with reactivated disease constitute the source for facility-wide outbreaks. Because many infected older residents do not present with the classic features of tuberculosis [17], infection in residents may remain unrecognized for prolonged periods of time, which sustains transmission. Accordingly, a number of tuberculosis outbreaks involving both residents and staff have been reported [16–18]. The CDC has published specific guidelines for the prevention of tuberculosis in nursing homes [16].

Pneumococci. Since 1990, ten reports have described outbreaks of *Streptococcus pneumoniae* in nursing homes and other LTCFs [19]. These have frequently occurred in facilities with low pneumococcal vaccination rates. Multidrug-resistant strains of *S. pneumoniae* accounted for 4 of these outbreaks. The largest involved a 100-bed nursing home in Oklahoma [20]. Eleven (13%) of 84 residents developed pneumonia, and 3 residents died. The outbreak strain, serotype 23F, exhibited resistance to penicillin, other β -lactam antibiotics, trimethoprim-sulfamethoxazole, erythromycin, clindamycin, and tetracycline.

Other infectious agents. Additional reports besides that of Loeb and colleagues [11] document the occurrence of outbreaks caused by RSV, parainfluenza virus, and *C. pneumoniae*.

Attack rates for RSV infection in nursing home outbreaks have ranged from 40% to 55%, and the spectrum of illness has ranged from mild colds to life-threatening respiratory distress [21]. Complications have varied considerably from one outbreak to another: pneumonia rates, for example, have ranged from 5% to 67%, and case-fatality rates have ranged from 0% to 53%. Attack rates for parainfluenza outbreaks have ranged from 20% to 30%, and 15%–45% of affected residents have developed pneumonia [21]; in one report, the case-fatality rate was 16% [22]. Of note, in one outbreak report, parainfluenza developed in one-third of staff with direct responsibilities for resident care. The attack rate for 3 outbreaks caused by *C. pneumoniae* in Ontario nursing homes ranged from 44% to 68% among residents, and it was 34% among the staff of one nursing home [23]. Of the 302 residents affected, 16 developed pneumonia and 6 died.

Single reports identify 5 other respiratory tract pathogens that have caused outbreaks in nursing home residents: *Chlamydia psittaci* [24], *Legionella pneumophila* [25], rhinovirus [26], *Haemophilus influenzae* type B [27], and *Bordetella pertussis* [28].

OUTBREAKS OF GASTROINTESTINAL (GI) TRACT INFECTION

Although the annual number of outbreaks of infection due to gastrointestinal pathogens in US nursing homes is not known, reports from various public health entities suggest that such outbreaks are frequent (table 2). In 1992, the New York State Department of Health received 188 reports of GI infection outbreaks in nursing homes in the state, representing 34.5% of all outbreaks reported that year [8]. Public health officials in Maryland reported 868 outbreaks of GI infection in 250 different facilities during the period from January 1986 through December 2000 [29]. From 1975 through 1987, the CDC investigated 115 outbreaks of foodborne disease in nursing homes located in 26 states [7]. Similar data have been reported from other Western countries. For instance, 314 GI infection outbreaks in LTCFs occurred in England and Wales during the period 1992–1994 [30].

Certain characteristics of the nursing home environment and its residents facilitate the acquisition and transmission of GI infection [31, 32]. Age-related achlorhydria increases susceptibility, as does frequent use of antimicrobial agents, which renders residents vulnerable to GI infection and chronic carriage of enteric pathogens. Residents who have dementia, incontinence, and behavioral disturbances may share crowded living spaces and bathroom facilities, facilitating person-to-person transmission of GI pathogens. Fomites such as rectal thermometers and soiled linen can transmit GI pathogens as well [33, 34]. Foodborne outbreaks may derive from on-site

preparation of meals for large numbers of residents, provision of diets of pureed food, and tube feeding of residents. These factors account for high attack rates, which have exceeded 50% in some reports [29, 32].

The majority (51%) of deaths from diarrheal illness occur in elderly persons, and 30% of these deaths among older persons occur among nursing home residents [35]. In the CDC's review of foodborne outbreaks in nursing homes, Levine and colleagues [7] reported that 4944 people became ill, 213 required hospitalization, and 51 died. These cases represented only 2% of all outbreak-associated illnesses and hospitalizations but represented 19% of deaths. The case-fatality rate for nursing home outbreaks of diarrheal illness exceeded that for other settings by 10-fold (1.0% vs. 0.1%).

Viral agents. Viruses cause the majority of outbreaks of GI infection in nursing homes [32]. In the 15-year period from January 1986 through December 2000, it appears that viruses accounted for 97% of the 868 GI infection outbreaks in Maryland nursing homes [29]. Attack rates ranged from 5% to 59% (median, 27%) for residents and from 0.6% to 26% (median, 9%) for staff. Investigations conducted in Australia, England, Wales, and The Netherlands also testify to the high frequency of outbreaks in LTCFs caused by viral agents [30].

Recent studies have confirmed the dominant role played by the Caliciviridae family, which are small round-structured viruses and include Norwalk virus and Norwalk-like viruses (e.g., Snow Mountain virus) [29, 32]. Analysis of stool specimens obtained during 20 GI infection outbreaks in Maryland nursing homes that occurred in the winter of 1987–1988 indicated that Norwalk-like viruses were responsible for 80% of the outbreaks [29]. Rotaviruses and enteric adenoviruses have accounted for some of the other outbreaks. In contrast to outbreaks of GI infection caused by bacteria, viral outbreaks occur more frequently during the winter months.

Salmonella species. These pathogens are a frequent and deadly cause of GI infection outbreaks among nursing home residents. In the review of CDC investigations between 1975 and 1987, *Salmonella* species accounted for ~20% of foodborne outbreaks and related illnesses in nursing homes and for nearly 75% of deaths [7]. In this review, *Salmonella* serotype Enteritidis was the most common cause of *Salmonella* infection outbreaks (26%), cases (28%), and associated deaths (50%). A 1970 outbreak in a Maryland nursing home caused by this same serotype affected 72% of residents and 29% of staff and resulted in 25 deaths [32]. CDC surveillance data for 1993–1997 indicated that serotype *S. Enteritidis* causes the most deaths in foodborne outbreaks, and that 40% of these deaths occur in nursing home residents [36]. Many other *Salmonella* serotypes have been implicated in nursing home outbreaks.

Escherichia coli O157:H7. This organism also causes GI infection outbreaks in nursing homes with significant morbidity

and high case-fatality rates. In a 1985 outbreak, 55 of 169 residents became ill, as did 18 staff members [37]. Twelve residents developed hemolytic uremic syndrome, and 19 died. Improper food handling initiated the outbreak, and it appeared that person-to-person transmission propagated it. In 1984, twenty-two cases of bloody diarrhea due to infection with *E. coli* O157:H7 occurred in a 101-bed nursing home in Nebraska [38]. Hamburger was the likely source. Fourteen residents required hospitalization, 1 developed hemolytic uremic syndrome, and 4 died.

Clostridium species. Both *Clostridium difficile* and *Clostridium perfringens* have caused outbreaks of GI illness and associated deaths in nursing homes. Reported rates of *C. difficile* colonization in LTCF residents range from 4% to 20%; when outbreaks of infection occur, they can be severe [39]. For example, a 1985 outbreak in a Baltimore nursing home resulted in 49 cases of infection and 19 deaths [40]. This outbreak persisted for 7 months, despite institution of enteric precautions, restrictions on antimicrobial use, and treatment of all *C. difficile*-colonized residents with metronidazole.

Between 1975 and 1987, CDC investigated 6 outbreaks of *C. perfringens* infection in nursing homes. These outbreaks affected 496 residents and resulted in 2 deaths [7]. Improper food handling caused an outbreak of *C. perfringens* infection in an Australian LTCF, which caused disease in 21 (55%) of 38 residents eating diets of pureed food [41].

Other infectious agents. Between 1975 and 1987, enterotoxin-producing strains of *Staphylococcus aureus* accounted for 12 of 63 foodborne outbreaks that occurred in nursing homes and were investigated by the CDC [7]. Although less common, *Shigella* species, *Campylobacter jejuni*, *Bacillus cereus*, and *Aeromonas hydrophila* also have accounted for some outbreaks [7, 42–44]. Rare reports have implicated the parasitic agents *Entamoeba histolytica*, *Giardia lamblia*, and *Cryptosporidium parvum* as causes of outbreaks of GI infection in nursing homes [32, 45, 46].

OUTBREAKS OF SKIN AND SOFT-TISSUE INFECTION

Group A Streptococci. Infection with *S. pyogenes* frequently gives rise to skin and soft-tissue infection, as well as respiratory tract infection [2, 6, 47, 48]. In published reports, skin and soft-tissue infections have included cellulitis, wound infection, conjunctivitis, impetigo, and necrotizing fasciitis. Respiratory tract infections have included pharyngitis, bronchitis, and pneumonia. Bacteremia, infection of distant body sites, and streptococcal toxic shock syndrome have complicated both dermatological and respiratory tract infection in outbreaks in nursing homes and in other settings.

The frequency of outbreaks of *S. pyogenes* infection in nurs-

ing homes is unknown; however, during the period 1989–1991, the CDC received requests to investigate 9 outbreaks that occurred in different facilities in different states [6]. Invasive disease, which is defined by isolation of *S. pyogenes* from normally sterile body sites and associated with high case-fatality rates (mean, 48%), characterized outbreaks in 5 nursing homes, which affected a total of 25 residents. In the other 4 outbreaks, which affected a total of 66 residents, noninvasive disease predominated and case-fatality rates averaged 8%. Noninvasive disease also characterized the 4 outbreaks previously reported in the literature. Of note, 4 of these 13 reported outbreaks lasted for 6–12 months [6].

Identification of sources for outbreaks reported in the literature has proved difficult. Similarly, investigations have seldom pinned down mechanisms of transmission with precision. Nevertheless, in one study, introduction of the pathogen via a nursing assistant seemed likely, and, in another study, intra-facility transmission via an infected nurse appeared probable [47, 48]. Resident-to-resident, staff-to-resident, and resident-to-staff transmission of *S. pyogenes* via respiratory droplets or direct contact constitute the probable mechanisms of dissemination and dictate the strategies for intervention described by Schwartz and Ussery [6].

Sarcoptes scabiei var. hominis. This arachnid, which causes the skin infestation scabies, may cause outbreaks of infection in nursing homes [24, 49]. The Iowa Department of Public Health (Des Moines) reported that 36 LTCFs had outbreaks of scabies during the period 1979–1987 [50]. Similarly, a 1982 survey in Michigan indicated that 27 nursing homes had outbreaks of scabies in the previous year [50]. Outbreaks start insidiously, last for months, and involve large numbers of residents, caregivers, and their families. A report from Oslo, Norway, for example, describes a 5-month outbreak in 3 LTCFs that affected 27 residents and health care workers [51]. Eventually, >600 residents and staff required treatment to terminate the outbreak. Degelau [50] has outlined a practical and detailed approach to management of facility outbreaks.

OUTBREAKS CAUSED BY ANTIMICROBIAL-RESISTANT BACTERIA

The frequent transfer of patients from acute care facilities to nursing homes allows introduction of antimicrobial-resistant bacteria via patients who are either colonized or infected with these microorganisms [52, 53]. These organisms tend to persist and become endemic. Deciding when the outbreak has ended and the endemic phase has begun is not always easy. Most studies in the setting of nursing homes describe patterns of colonization and infection during the endemic phase. However, a few studies describe nursing home outbreaks, which usually correspond to initial experiences of facilities with these agents,

when infectious morbidity is conspicuous. Of note, recommendations for control of outbreaks caused by antimicrobial-resistant bacteria in nursing homes are available [52, 53].

Methicillin-resistant *S. aureus* (MRSA). Although many nursing homes have reported their extensive experience with MRSA infection, only 2 reports identify outbreaks of symptomatic disease. Storch and colleagues [54] described an outbreak of MRSA infection in a St. Louis–area nursing home that occurred during a community-wide influenza outbreak in 1985. The transfer of 5 residents with MRSA pneumonia to a local hospital led to the detection of the outbreak. The likely source was a resident transferred to the nursing home from a local hospital 6 months earlier. MRSA entered our nursing home in 1987 [55] and, during the 2-year period after its arrival, we detected 16 MRSA infections. Thereafter, MRSA infection rates stabilized as a relatively fixed proportion of all *S. aureus* infections [56].

Vancomycin-resistant enterococci (VRE). Most reports of VRE infection outbreaks in nursing homes, like that reported by Armstrong-Evans and colleagues [57], mention only colonized residents. Symptomatic disease caused by VRE appears infrequently in these circumstances. However, Bonilla and colleagues [58] did observe 7 VRE infections in residents of their LTCF during the 30-month period after the entry of this pathogen into their Veterans Affairs medical center. They also noted that these patients had been hospitalized on multiple occasions at their acute care hospital before developing VRE infection at their nursing home facility. Accordingly, it is unclear whether these infected patients acquired VRE in their acute care division or nursing home facility.

Multidrug-resistant (MDR) gram-negative bacilli (GNBs). Multiple studies have reported MDR-GNBs, especially uropathogens, in nursing homes [52], but only 2 have described outbreaks. Rice and colleagues [59] described an outbreak caused by ceftazadime-resistant GNBs that affected 29 residents in an LTCF in Massachusetts. Ceftazadime resistance arose in *Klebsiella pneumoniae* and other members of the family Enterobacteriaceae from transmission of plasmids coding for 2 distinct extended-spectrum β -lactamases. More recently, Wiener and colleagues [60] described a citywide, nursing home-centered outbreak of infection caused by extended-spectrum β -lactamase-producing GNBs. Their report focused on 35 patients who were colonized or infected with strains of *K. pneumoniae* and *E. coli* that produced a common extended-spectrum β -lactamase and who had been transferred to their hospital from 8 nursing homes.

CONCLUSION

Available reports describing outbreaks of infectious diseases in nursing homes indicate how common and severe they can be.

They underscore the need for outbreak management plans as well as active infection-control programs in these facilities. They also raise another key issue: the need for better surveillance and additional study. The creation of a national registry or other unified data bank, for example, could improve understanding of the epidemiology of outbreaks in nursing homes immensely. Better information about the magnitude of the problem and the characteristics of facilities that experience outbreaks would likely help clinicians delineate better strategies for prevention and control.

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