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Common infections in nursing homes: a review of current issues and challenges

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Abstract

Over 1.5 million people live in 16,000 nursing homes in the USA and experience an average of 2 million infections a year. Infections have been associated with high rates of morbidity and mortality, rehospitalization, extended hospital stay and substantial healthcare expenses. Emerging infections and antibiotic-resistant organisms in an institutional environment where there is substantial antimicrobial overuse and the population is older, frailer and sicker, create unique challenges for infection control. This review discusses the common infections, challenges, and a framework for a practical infection prevention program.

Keywords

antibiotic-resistant organisms; infection control program; infection prevention; infections; multidrug-resistant organisms; nursing home

Impact of infections in nursing homes

Over 1.5 million people live in 16,000 nursing homes (NHs) in the USA, according to the 2004 National Nursing Home Survey. More than 88% of these people are 65 years of age and older, and 45% are age 85 years and older [1]. It is estimated that the number of people who will require NH care in the USA will reach 5.3 million by 2030 [2]. The acuity of illness in this population has increased substantially in the last decade, as has the risk of acquiring new infections. Although recent estimates are lacking, approximately 2 million infections occur in US NHs each year [3]. In addition, a point prevalence survey revealed that the prevalence of NH-associated infections on the day of the survey was 5.2% in Veterans Administration (VA) Community Living Center (CLC) facilities in the USA [4]. Internationally, a 3-year study in The Netherlands reported a prevalence of healthcare-associated infections of 6.7% in 2007, 7.6% in 2008 and 7.6% in 2009, ranging from 0 to 32.4% between NHs [5].

Infections in the NH population have been associated with high rates of morbidity and mortality, rehospitalization, extended hospital stay and substantial healthcare expenses. Risk factors that predispose older adults to infections have been well described and include the presence of indwelling devices, recent admission to an acute care facility, functional

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impairment and multiple comorbidities [3]. For example, NH residents with feeding tubes are susceptible to aspiration pneumonia (15–23%), local skin and soft tissue infections, as well as other mechanical complications [6,7]. Furthermore, in a review on patients with dementia, mortality rates due to pneumonia were found to be higher in tube-fed patients than in orally fed patients [8]. Similarly, NH residents with urinary catheters are more prone to urinary tract infections (UTIs), bacteremia and septicemia [3]. Functional status has a circular relationship with infection susceptibility: poor function predisposes older adults to infections and infections, in turn, lead to further functional disability.

Infections and the resultant use of antibiotics is a key reason for the emergence of antibiotic-resistant organisms (AROs) in NHs. Common AROs in NHs include methicillin-resistant *Staphylococcus aureus* (MRSA), resistant Gram-negative bacilli and vancomycin-resistant enterococci. NH residents who are transferred back to the hospital, transferred to a different NH, or transitioned to home or hospice facilities, serve as vectors, frequently introducing AROs into their new locations [9]. Colonization is often a prerequisite for infection, and the same colonizing ARO strain can also lead to infection. Such infections may be difficult to treat. The risk factors for ARO colonization and infection include age, functional status, longer term institutionalization, prior antibiotic exposure, presence of an indwelling device and comorbidities [10]. We review common infections in NHs, emerging challenges to infection prevention in this setting, and propose a framework for an effective infection prevention program.

Common infections in NHs

Urinary tract, respiratory and skin and soft tissue infections are the most common endemic infections among NH residents. Epidemic infections most commonly reported include gastroenteritis, influenza and skin infections [11]. Precise estimates on the prevalence and incidence of infections in NHs are difficult to obtain due to a remarkable diversity in those being cared for in this setting. The 2004 Nursing Home Survey reported a 2.3% prevalence rate for pneumonia and a rate of 5.7% for UTIs in NH residents older than the age of 65 years [1]. A survey of 15 NHs in the UK in 2006 reported an incidence rate of 6.04 infections/1000 bed-days. The incidence rates for the main categories of infection were 2.52 infections/1000 bed-days for respiratory infections, 1.87/1000 bed-days for urinary infections, 1.57/1000 bed-days for skin and soft tissue infections, and 0.41/1000 bed-days for gastrointestinal infections [12]. In a study to evaluate attributable rates of infections in NH residents with indwelling devices, we showed that the incidence rate of all infections among residents with either a feeding tube or a urinary catheter was 331 infections/1000 resident- months or 11.03 infections/1000 resident-days. The incidence rate of infections in nondevice residents was substantially lower at 171 infections/1000 resident-months or 5.7 infections/1000 resident-days, with a relative risk of 1.9 (95% CI: 1.4–2.6) [13]. For the purposes of this review, we focus on the four most common infections: pneumonia, UTIs, diarrheal illnesses, and skin and soft tissue infections.

Pneumonia

Pneumonia and lower respiratory tract infections remain the leading cause of mortality in NH residents and a primary reason for resident transfer to a hospital. The incidence of NH-associated pneumonia varies from 0.3 to 2.3 episodes per 1000 resident care days [14]. These rates vary based on specific risk factors. For example, in our study, residents with feeding tubes had an incidence rate of 3.7/1000 resident-days, substantially higher than residents without feeding tubes (incidence rate of 1.1/1000 resident-days) [13]. It has been reported that NH residents in the USA account for 10–18% of all people hospitalized for pneumonia, corresponding to an average hospital cost of approximately US $10,000 per admission [15].

Pneumonia can manifest in the elderly with some atypical signs and symptoms, and may constitute a challenge for diagnosis in the NH setting. Indeed, 25% of older adults may not develop fever in the presence of pneumonia and other infectious processes, and are less likely to complain of chills, myalgia and pleuritic chest pain compared with younger patients [16]. Chest radiographs are helpful to define the presence of a new infiltrate, the severity of the disease and the presence of complications. However, some NHs have limited or no access to radiological services, and the diagnosis is made clinically.

Outbreaks of seasonal influenza are reported frequently. Fortunately, outbreaks of the most recent pandemic strain have been fewer. In the USA, during the 2009 pandemic, influenza A (H1N1) outbreaks were reported in NHs in three states. Staff attack rates in these outbreaks ranged from 5 to 40% and the resident attack rate from 6 to 28% [17]. Older adults usually have fewer typical signs and symptoms of influenza, making early diagnosis and prompt treatment difficult. As a result, it becomes prudent to annually immunize older adults and their healthcare workers (HCWs) against influenza. Several studies have shown a reduction in mortality of older adults if their HCWs have been immunized [18]. Along with immunization, neuroaminidase inhibitors, such as zanamavir and oseltamivir, can be used for prophylaxis and treatment of influenza A and B.

Aspiration pneumonia is common in the NH population and is often associated with oropharyngeal dysphagia and regurgitation of gastric contents. Inadequate oral care significantly increases the risk for developing pneumonia [19]. Dental plaque has been particularly studied as a source of bacteria that may cause respiratory infections. A study in Japan showed an association between periodontal disease and increased mortality from pneumonia [20]. Another study of 137 NH residents revealed that 58% had extensive oral needs, and 30% reported a severe impact on their oral health-related quality of life [21]. These studies emphasize the need to provide adequate oral care to NH residents.

A systematic review of randomized controlled trials reveals that oral hygiene has positive preventive effects on pneumonia and respiratory tract infections in elderly hospitalized patients and NH residents, with absolute risk reductions of 6.6–11.7% [22]. Another study of 143 residents in a VA NH investigated the association between the assignment of an oral hygiene aide and mortality from pneumonia, and found that the odds of dying from pneumonia in the group that did not receive oral care were more than three-times those of the group receiving oral care (odds ratio = 3.57; $p = 0.03$) [23]. However, the lack of a designated person to provide oral care, lack of knowledge and training of nurse aides, resident noncompliance (frequently seen in patients with dementia), refusal of oral care, and lack of dental coverage (Medicare) severely limit oral care in older adults [24]. These studies underscore the need for implementation of a dental care program in NHs.

Urinary tract infection

UTI is the most common infection and perhaps the most over-diagnosed infection in NHs. The presence of an indwelling urinary catheter increases the risk of both UTIs and bacteriuria. For example, approximately 3–7% of NH residents with an indwelling urinary catheter will acquire a UTI with each day the catheter remains in place. By day 30 following catheter insertion, the prevalence of bacteriuria is almost 100% [25]. It is estimated that 50% of NH residents with a urinary catheter will have symptomatic catheter-related UTIs. In addition, residents with urinary catheters for longer than 30 days have a mortality rate higher than residents without a catheter [26]. Our data show that residents with indwelling urinary catheters have an incidence rate of 9.1 UTIs/1000 resident-days, significantly higher than 2.8 UTIs/1000 resident-days in the nondevice group [13].

Guidelines to prevent indwelling catheter-associated UTIs include limiting the use of urinary catheters, minimizing the duration of urinary catheter use, diligent hand hygiene before and after any manipulation of the catheter, using aseptic technique to insert the catheter, maintaining a closed drainage system, and keeping the retention bag below the level of the bladder [27,28]. Wide discrepancies remain between research-proven recommendations pertaining to urinary catheter care and HCWs' knowledge. In a study to assess the awareness of current evidence-based urinary catheter care practices among skilled HCWs in NHs – both nurses and nurse aides – we showed that over 90% of survey respondents were aware of measures such as cleaning around the catheter daily, glove use, and appropriate hand hygiene with catheter manipulation. Unfortunately, in a study analyzing urinary catheter care knowledge, we found a significant disparity between research-proven recommendations and HCW knowledge: 25% of respondents were unaware of indications for long-term catheter use, 55% were unaware of recommended practices to maintain a closed drainage system, and 70% were unaware of current recommendations against the practice of routine bladder irrigation [29].

McNulty *et al.* conducted a self-reported survey of 'nursing' staff including registered nurses, as well as matrons and 'other care' staff that included student nurses, care assistants and domestic/housekeeping staff in 37 UK NHs. They report that 83% of all nursing staff received formal training in urinary catheter care compared with 40% of the 'other care' staff. Yet, a majority of both the groups participated in urinary catheter care including emptying and changing the catheter bag, and obtaining a urinary sample. Hand hygiene and glove use remained high but routine bladder irrigation was common, contrary to the UK NICE recommendations [30]. Findings from these studies provide specific areas for practice improvements as HCWs in NH settings take care of an increasingly sicker and larger population. These studies should also lead to innovative educational strategies for NH HCWs.

Diarrheal diseases

Viral and bacterial gastroenteritis cause the majority of diarrheal outbreaks in NHs. Older adults are known to have a decreased production of gastric acid, and therefore, are at a higher risk for developing infectious gastroenteritis. The clinical course of gastroenteritis is usually self-limited. However, in older NH residents, gastroenteritis can be associated with increased morbidity and mortality, largely due to a higher risk for dehydration. Studies indicate that older NH residents are four-times more likely to die from gastroenteritis than community-dwelling older adults [31,32]. A study in Australia that analyzed gastroenteritis outbreaks from 2002 to 2008 reported that 52% of outbreaks of gastroenteritis and food-borne disease occurred in the NH setting; 0.19 residents affected/1000 resident-days and 16.8 outbreaks/100 NHs per year. Among those affected, 6.4% were hospitalized and 2.7% died. Norovirus was found to be responsible for 1136 (35%) of the 3257 outbreaks [33].

Norovirus remains a common cause of gastroenteritis and is responsible for more than 50% of all gastroenteritis outbreaks worldwide [34]. It has been estimated that 21 million illnesses caused by norovirus occur each year in the USA [35]. This virus is considered to be very contagious and can be transmitted person-to-person, or through food and water. NHs are a frequent site for these outbreaks. In fact, 35% of the 660 norovirus outbreaks reported by the CDC in 1994–2006 occurred in NHs [36]. Norovirus outbreaks in NHs can be prolonged, so instituting a prompt infection control plan is critical. Such a plan should include appropriate hand hygiene, isolation of symptomatic patients, exclusion of affected staff, restriction of new admissions into affected units, and use of chemical disinfectants (sodium hypochlorite). All outbreaks of acute gastroenteritis must be reported to state health departments.

Clostridium difficile is an emerging cause of infectious diarrhea in NHs. The incidence of asymptomatic colonization with *C. difficile* in NHs varies from 4 to 20%. It has been estimated that 8–33% of NH residents treated with antibiotics acquire *C. difficile*. Nearly 10–30% of NH residents are colonized with *C. difficile* at any given time [37]. As expected, higher rates of *C. difficile*-associated diarrhea have been reported in residents of subacute care units. In the USA, these are for patients recently transferred from acute care hospitals who require lower levels of care. The major risk factors for *C. difficile* infection in NHs include age, previous antibiotic use, a recent hospital stay, use of acid suppressants, and presence of nasogastric or gastrostomy feeding tube [38–41]. The clinical spectrum of illness caused by *C. difficile* ranges in severity from an asymptomatic carrier state to self-limited mild and watery diarrhea to life-threatening pseudomembranous colitis, fulminant colitis and death [40].

Over the last decade, the incidence and severity of *C. difficile* infection has increased exponentially. A new hypervirulent strain of *C. difficile*, known as group B1, North American pulsed-field type 1, or PCR ribotype 027 (B1/NAP1/027) has been identified. This strain has several virulence factors such as higher production levels of *TcdA* and *TcdB*, production of a binary toxin (that may in turn enhance the toxicity of *TcdA* and *TcdB*), and a rapid rate of spore formation [42]. This new *C. difficile* 027 strain has been identified in outbreaks in both the USA and Europe (75 hospitals in England, 16 hospitals in The Netherlands, 13 healthcare facilities in Belgium and nine healthcare facilities in France [43]).

C. difficile constitutes a particular challenge for infection prevention and control in NHs. NH residents typically socialize in common areas. NHs also have limited or no areas for isolating infected residents. *C. difficile* persists in the environment as spores that contaminate inanimate surfaces such as bed rails, furniture, toilets, bedpans, weight scales, therapy equipment and medical equipment. This widespread contamination potential increases the possibility for cross-transmission to other vulnerable older adults, as well as HCWs and visitors. *C. difficile* spores are notoriously difficult to eradicate from these surfaces; commonly used detergent-based cleaners are not effective, although a 10% bleach solution is effective [44]. The CDC recommends using US Environmental Protection Agency (US EPA)-registered disinfectants with a sporicidal claim for environmental surfaces in contaminated patient areas. Since alcohol-based hand gels are not sporicidal, appropriate hand hygiene with soap and water is required to remove spores from skin surfaces. Appropriate signage and staff education are crucial to enhance adherence to this recommendation.

Skin & soft tissue infections

Older NH residents are particularly predisposed to skin and soft tissue infections due to several physiologic changes that occur with aging, including atrophy of epidermis and dermis, reduced resistance to external insults, and prolonged wound healing. Dry pruritic skin can serve as a portal of entry for pathogens. Acute bacterial infections in NHs include cellulitis, erysipelas and necrotizing fasciitis. Chronic wound infections, which are more common, include infected pressure ulcers, diabetic wound infections and vascular ulcers. Other skin infections include intertrigo, tenia versicolor, viral skin infections such as herpes zoster and simplex, and scabies.

Pressure ulcers in NHs are frequent and preventable as well as being a quality of care indicator. Risk factors that predispose to pressure ulcers include immobility, incontinence, impaired cognition, greater acuity of care and impaired nutrition. Frail older adults with pressure ulcers are at risk for developing infections that may vary from cellulitis to osteomyelitis, bacteremia, septicemia and death. It is important to recognize these infections

early and treat them appropriately. Pressure ulcers, like the skin, are colonized with bacteria. Therefore, antibiotic therapy is not appropriate for positive surface-swab culture without signs or symptoms of infection. Pressure ulcer sites should be examined daily for typical signs of infection such as an increase in temperature, erythema, tenderness, discharge and presence of foul smell. This examination is valuable since systemic signs such as fever and leukocytosis are often absent. Clinical examination does, however, underestimate the degree of deep tissue involvement. Deep tissue biopsy may help in directing antibiotic therapy. Osteomyelitis from an infected pressure ulcer does occur in this setting, largely in immobile older adults with compromised nutrition. Confirming clinical suspicion with an MRI scan or a fine-needle biopsy helps direct the duration of antibiotic use.

Scabies is a common ectoparasitic skin infection seen in the NH population. Infestation with the classical human scabies mite (*Sarcoptes scabiei var. hominis*) is characterized by intense itching (pruritus), a rash, and secondary infection, as well as superficial burrows where mites tunnel under the skin of their hosts. Crusted scabies (caused by *Scabies crustosa* or *Scabies norvegica*) is often difficult to diagnose in NH residents. It is usually necessary to confirm scabies, since it has major infection control implications to the NH staff including environmental and housekeeping services, residents, visitors and families. The most common method to diagnose scabies is by skin scraping with a scalpel covered with oil, followed by direct microscopic visualization.

The recommended topical treatment for classical scabies includes 5% permethrin, 1% lindane, 0.05% malathion, 10% crotamiton or 25% benzylbenzoate cream or solution. Permethrin has been found to have significantly higher efficacy when compared with lindane [45]. After topical application, the medication must be left on for approximately 8–12 h, and reapplication after 1 week is recommended [45]. Crusted scabies is a rare variant of classical scabies. It is highly contagious, and is usually seen in immunocompromised patients. In these cases, systemic treatment with oral ivermectin at a dose of 200 mcg/kg with a repeat dose after 7 days has been recommended [46]. Important measures to prevent transmission and outbreaks include patient isolation, cleaning and eradication of fomites, clipping of elongated nails, repeat treatment after 1 week, ensuring appropriate hand hygiene and glove use, and treatment of all HCWs and family members who have been in contact with the patient [47].

Challenges to infection prevention programs: old & new

The changing host

It is well known that NH residents are at risk of infection because of frequent hospital stays, advanced age, exposure to multiple courses of antibiotics and numerous comorbidities. Older adults also have a diminished immune response including phenotypic and functional changes in T-cells. Other factors include malnutrition, multiple comorbidities and polypharmacy, with use of medications that may diminish host defenses. In addition, older adults with cognitive impairment may not be compliant with personal hygiene and hand washing, and may have functional impairment that leads to immobility, and urinary and fecal incontinence, thereby increasing their risk for acquiring new infections and for transmission of those infections.

NHs are constantly evolving. Efforts to reduce healthcare costs have led to a reduced number of hospitalizations and shorter lengths of stay (with a resulting increase in severity of illness and intensive care unit admissions), along with increased outpatient and home care, and NH stays for older adults. As a consequence, NHs and rehabilitation units are seeing sicker patients, who require more intense medical supervision and are more prone to infections, as well as antimicrobial resistance. While the prevalence of chronic indwelling

urinary catheters has gone down, use of short-term urinary catheters and peripherally inserted central catheters has increased. According to the 2004 Nursing Home Survey, 42% of NHs provide infusion therapy, 22% have residents with peripherally inserted central catheters and 46% provide total parenteral nutrition [1]. This increased use of NHs and rehabilitation units to provide higher levels of care than ever before translates to a higher potential for more infections, higher antimicrobial use and the resultant emergence of AROs.

Noncompliance with standard precautions and shared use of glucose monitoring devices in NHs have placed residents at risk for acquiring blood-borne pathogens such as hepatitis B virus, hepatitis C virus and HIV. Hepatitis B virus outbreaks have become more frequent in the last decade, affecting NH residents with diabetes [48]. In 2005 alone, three hepatitis B virus outbreaks among residents of NHs were reported by the CDC. These outbreaks were attributed to shared devices and breach in infection control practices while monitoring blood glucose [49]. A systematic review of reports of 33 hepatitis B outbreaks caused by patient-to-patient transmission in the USA and Europe involved 471 patients; 21% of the cases involved NHs [50]. In order to prevent patient-to-patient transmission, NH staff should avoid carrying and sharing glucose monitoring supplies from resident to resident, reduce the number of percutaneous procedures to the minimum necessary, and they should use appropriate hand hygiene.

Promoting appropriate hand hygiene

The single most important aspect of an infection prevention and control program is hand hygiene. While guidelines have been published on hand hygiene, compliance among HCWs remains well below 50%. Studies on the effectiveness of multifaceted hand hygiene programs have shown some effectiveness. For example, a study in a Taiwan NH showed that nursing assistants had significantly more knowledge and better compliance after hand hygiene training [51]. Moreover, a recent study conducted in four healthcare settings (acute care geriatric wards, skilled NHs and physical rehabilitation units), demonstrated a significant improvement for hand hygiene and gloving practices [52]. Thus, hand hygiene and other infection control programs should be extended to other HCWs such as physical therapists, occupational therapists, social workers and nutritionists, since they have frequent contact with NH residents [53].

Frequent care transitions

Older NH residents are prone to transfer between locations or different levels of care within the same facility. These locations can include acute care hospitals, NHs, skilled nursing facilities, rehabilitation units, home care, outpatient care including same-day surgical units, outpatient infusion rooms, dialysis units, and outpatient primary and other specialty clinics. During these transitions, residents are susceptible to care fragmentation, which may lead to medical errors and poor quality care. These transitions also provide an opportunity for pathogens to be transferred from one setting to another and one person to another, as well as prescription drug errors including choice of antibiotics, dosage and duration.

These care transitions invariably lead to practical dilemmas in exercising isolation practices. For example, a NH resident with MRSA could be confined to their room during their acute care stay, but may not be isolated in the skilled nursing facility, again leading to confusion among HCWs, patients and families. In other words, infection control issues in older adults vary as they move through various healthcare settings due to the type of care provided, patient characteristics, the unique need for social and personal contact in older adults, and staff and facility resources. Enhanced and prompt communication with the transferring hospitals and all involved individuals is a simple strategy to minimize this confusion and avoid transmission of AROs from one setting to another.

Persistent & emerging AROs

It is estimated that a third of the 1.5 million NH residents in the USA are colonized with at least one ARO. MRSA is the most common ARO studied. Cross-sectional point prevalence studies in NHs show a wide range of colonization rates, with 10–50% of residents colonized with MRSA [54,55].

Resistance to third-generation cephalosporins has been increasing in the NH setting. Only one of 252 (0.4%) *Escherichia coli* clinical isolates from three VA CLCs tested between 1995 and 1997 was resistant to ceftazidime [55]. In a follow-up study, 12% of 806 clinical isolates of *E. coli* from one of these VA CLCs tested in 2008 were resistant to ceftazidime. Similarly, while none of the 121 *Klebsiella spp* clinical isolates from VA CLCs in 1995–1997 were resistant to ceftazidime, 28% from NHs tested in 2008 were resistant to it [56]. More recently at another VA CLC, the percentage of Gram-negative bacteria (GNB) that were ceftazidime-resistant in CLC colonizing strains (19.3%) or CLC clinical strains (15.0%) was no different when compared with ceftazidime-resistant rates for the acute care hospital affiliated to the CLC (16.7%) [57].

Colonization of ciprof loxacin-resistant (CIP-R) GNB has now surpassed ceftazidime-resistant GNB rates. In 1998, the prevalence of CIP-R GNB in rectal surveillance cultures was 2.6% in California NH residents [58]. In another study that involved 14 NHs in the USA from March 2003 through to November 2004, over 54% of the device group and 35% of the control group were colonized with CIP-R GNB [59]. In addition to indwelling devices, other risk factors for a high prevalence of AROs include functional impairment, prior hospitalization and prior antimicrobial usage; they are all considered to increase the colonization risk of multiple AROs. Another study in 16 NHs in the UK from 2004 through to 2006 reported that more than 40% of residents had extended-spectrum β-lactamase-producing CIP-R *E. coli*; however, 51% had no history of recent hospital admission, and only 13% had a history of extended-spectrum β-lactamase *E. coli* colonization or infection. These results are concerning since NHs may be a potential reservoir for AROs and play an important role in their transmission [60].

Strategies to prevent new acquisition of AROs and curb their transmission in the NH setting include education of HCWs, targeted surveillance and feedback, facility-appropriate antibiotic stewardship programs and diligent hand hygiene [9,11,34,38,51,53]. Hand carriage by HCWs can result from direct contact with residents' secretions during care or indirect contact with their environment. Direct contact is an effective way of transmitting pathogens to other residents and locations. Frequent hand washing with appropriate products including alcohol-based hand rub can remove transient flora on HCWs' hands [11,57]. Contact precautions are usually advised for HCWs who work with NH residents with AROs. HCW precautions include using gowns and gloves for all resident interactions including those within his/her environment, as well as eye gear if appropriate.

Inappropriate antimicrobial use

Empiric and often inappropriate antimicrobial use is extensive in all settings, but particularly in NHs. Studies reviewing antibiotic use in long-term care facilities reveal that from 50 to 75% of residents are exposed to one or more courses of antibiotics over a 12-month period [37]. A clinical course of antibiotics is frequently initiated in the absence of adequate clinical evaluation and diagnostic information including the presence of fever, elevated white blood cell count, positive culture or susceptibilities to specific antibiotics. For example, up to a third of prescriptions for suspected UTIs in NH residents are for asymptomatic bacteriuria. Inappropriate antibiotic usage includes errors in choice, duration or dosage, as well as using antibiotics to treat viral infections [61]. Unnecessary use of

antimicrobials and other systemic drugs can have dire outcomes in NH residents, such as drug interactions, adverse drug events, development of antimicrobial resistance and excessive preventable costs. While appropriate antimicrobial usage is ideal, actually practicing it in the NH setting is challenging, predominantly as a consequence of delay in diagnosis due to a paucity of clinical findings in older adults, presentation of infection with systemic symptoms (e.g., confusion and falls) rather than infection-specific presentation, lack of on-site diagnostics and an absence of on-site physicians or physician-extenders.

Several strategies have been proposed or studied to reduce inappropriate antimicrobial practices in NHs. These include antimicrobial utilization review by the infection control committee to monitor antibiotic prescription and usage, the development and promotion of programs to optimize judicious antibiotic use, and as needed audits to assess antibiotic appropriateness, prevalence of antibiotic resistance and antibiotic-related adverse events. A recent study in multiple NHs in the USA and Canada evaluated the effectiveness of a more proactive approach. This approach advocated the use of clinical algorithms targeted to physicians and nurses and implementing a multicomponent program of education, written material, real-time reminders and outreach visits to reduce UTIs [62]. They showed a 31% reduction in antimicrobial use for urinary indications; however, they did not show a reduction in overall antimicrobial use. Similarly in a study by Pettersson *et al.*, an educational intervention including small group educational sessions, feedback on prescribing and didactics on several guidelines led to reduced overall antibiotic prescriptions [63].

Defining preventable infections

Defining any infection in NHs is a challenge. Standard definitions of nosocomial infections were created to be applied to hospitals, and may not necessarily apply to the NH setting. NH residents typically present with atypical symptoms such as delirium, falls and/or loss of function, rather than the characteristic signs and symptoms of infection [11]. NHs often have limited access to laboratory and radiology services, in some cases causing delay of diagnosis of infections. Responding to these concerns, NH-appropriate infection surveillance definitions and minimum criteria to initiate antibiotics have been developed and should be used [64,65].

Debate on defining a preventable fraction of these NH-associated infections remains. Benchmarking a facility-specific average number of infections helps determine the number of infections that exceed this benchmark and thus could potentially be preventable. Other ways to define preventable infections in acute care include connecting specific infections to deviations in processes of care and designing risk stratification models to define high-risk versus low-risk individuals. While progress is being made in the acute care setting, there is a paucity of similar research in NHs [66,67].

Infection prevention & control programs in NHs

NHs in the USA accepting Medicare and Medicaid residents are now required to have a structured infection prevention and control program spearheaded by an infection control practitioner (ICP). This requirement has universally been embraced; however, the adoption, enthusiasm and leadership behind these programs vary substantially. The main functions and framework of an infection prevention and control program are outlined in Box 1. These programs are also taking a lead in patient safety and are a crucial part of overall quality improvement. Infection prevention and control programs have to conform to the overall care philosophy and culture of the facility. Details on an ideal infection prevention and control program have been well described in a recent review by Smith *et al.*, along with members of

the Society for Healthcare Epidemiology of America (SHEA) special interest group on long-term care [11,68].

An ideal ICP should be a champion for infection prevention, have a background in long-term care, as well as some exposure to infectious diseases epidemiology, microbiology and education. The ICP should also be familiar with the federal, state and local regulations regarding infection control, be able to align facility priorities with infection prevention, and be able to communicate with state and local public health offices. An alliance with and access to an infectious disease epidemiologist may also be helpful. These alliances will lead to enhanced communications between the stakeholders during emergencies such as pandemics, outbreak investigations, vaccine shortages or acts of bioterrorism.

In reality, it is usually a staff nurse who is responsible for an infection prevention and control program. These ICPs often also function as an assistant director of nursing and/or staff development. The number of hours spent on infection control activities usually depends on the number of beds, acuity of residents and type of facility. For an infection prevention and control program to be successful, the ICP should have full leadership support and decision-making authority.

NH infection and ARO rates, antibiotic use practices, hand hygiene and immunization programs should be routinely discussed with a subcommittee or a working group comprised of a physician/medical director, an administrator and the ICP. This committee would also review policies and any research in the area, and have decision-making authority to implement infection control policies in case of emergencies. The ICP and committee activities and priorities should be well documented and maintained.

The principles guiding infection prevention and control practices also provide a model for enhancing quality of care and patient safety for other noninfectious adverse outcomes such as falls, delirium, inappropriate medication usage and adverse drug events.

Conclusion & future perspective

The NH industry is undergoing significant evolution with an increasingly complex host, reducing reimbursements and higher expectations to reduce hospital transfers. Increasingly, NHs are taking care of older adults who are sicker, have recently been hospitalized and require more healthcare interventions. These patients are at higher risk of infections and antimicrobial exposure. On the other hand, hospitals are being incentivized to reduce readmissions resulting in fewer transfers from NHs to hospitals for infection management. Infection prevention and control programs will need to evolve to keep up with these changes in healthcare delivery. Patient-oriented research on strategies to enhance hand hygiene compliance, reduce transmission of AROs, and to develop infection prevention practices for nursing as well as other non-nursing direct care staff is urgently needed to enhance quality of care of older adults in the NH setting.

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Box 1. Framework of an infection control program in nursing homes

Infection surveillance

- A system for ongoing data collection on infections using written nursing home appropriate infection definitions such as McGeer's criteria should be present. The data should be reviewed frequently to identify trends and reported to both the administration and the oversight committee

Outbreak control

- Surveillance data should be used to detect, prevent and control outbreaks. Facilities should identify the authority to deal with outbreaks

Isolation and precautions

- Isolation and precaution policies and procedures should be developed, evaluated and updated in accordance with the most recent CDC/HICPAC guidance

Asepsis and hand hygiene

- Hand hygiene at various venues within the facility should be encouraged. A hand hygiene policy should be developed and disseminated within the facility. Hand hygiene compliance should be monitored

Resident care

- Resident care programs should include a resident skin care, urinary catheter, feeding tube and immunization program

Education

- Infection control in-services should be provided at the initiation of employment and regularly thereafter. Training should include all staff members

Antibiotic stewardship

- Nursing homes should encourage judicious use of antibiotics with guidance based on local susceptibility patterns

Regulatory aspects

- Infection control programs must be compliant with federal, state and local regulations

HICPAC: Healthcare Infection Control Practices Advisory Committee.

Data taken from [11].

Executive summary

- Over 1.5 million people live in 16,000 nursing homes (NHs) in the USA. More than 88% of NH residents are 65 years of age and older and 45% are 85 years of age and older.
- An average of 2 million infections occur in NHs in the USA per year. Urinary tract, respiratory and skin and soft tissue infections are the most common endemic infections among NH residents. Epidemic infections commonly reported include viral gastroenteritis (such as norovirus infections), influenza and skin infections (e.g., methicillin-resistant *Staphylococcus aureus* and skin and soft tissue infections).
- Infections in NH residents have been associated with adverse clinical outcomes, including high rates of morbidity and mortality, rehospitalization, prolonged hospital stay and substantial healthcare expenses.
- Antibiotic-resistant organisms are endemic in NHs and can cause infections that may be difficult and expensive to treat. Empirical and often inappropriate antimicrobial usage is extensive in all settings, but particularly in NHs.
- Older NH residents are prone to transfer between different locations or different levels of care in the same location. These locations can include acute care hospitals, NHs, skilled nursing facilities, rehabilitation units, home care, outpatient care including same-day surgical units, outpatient infusion rooms, dialysis units and outpatient primary and other specialty clinics.
- Most NHs in the USA have a structured infection prevention and control program, as well as an infection control practitioner assigned as a point person for the program.