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REVIEW

Reducing inappropriate antibiotic prescribing in the residential care setting: current perspectives

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Abstract: Residential aged care facilities are increasingly identified as having a high burden of infection, resulting in subsequent antibiotic use, compounded by the complexity of patient demographics and medical care. Of particular concern is the recent emergence of multidrug-resistant organisms among this vulnerable population. Accordingly, antimicrobial stewardship (AMS) programs have started to be introduced into the residential aged care facilities setting to promote judicious antimicrobial use. However, to successfully implement AMS programs, there are unique challenges pertaining to this resource-limited setting that need to be addressed. In this review, we summarize the epidemiology of infections in this population and review studies that explore antibiotic use and prescribing patterns. Specific attention is paid to issues relating to inappropriate or suboptimal antibiotic prescribing to guide future AMS interventions.

Keywords: residential aged care, health care-associated infection, surveillance, multidrug-resistant, antibiotic prescribing, antimicrobial stewardship

Introduction

Long-term care facilities (LTCF) refer to an array of residential and outpatient facilities designed to meet the biopsychosocial needs of persons with sustained self-care deficits.[1,2] These include residential aged care facilities (RACFs), nursing homes, skilled nursing facilities, assisted living facilities, retirement homes, and so on. In the literature, these terms may vary across different geographical areas; for instance, LTCF is a term more frequently used in the United States, whereas the term RACF is more commonly applied in other countries like Australia. In general, there is considerable overlap between an LTCF and an RACF; all of these terms refer to a health care setting that provides long-term nursing care to the elderly in the community.[2] This article is mainly focused on studies described in the context of RACFs and/or nursing homes, with less emphasis placed on other LTCF settings, unless otherwise specified. The term RACF, instead of LTCF, will be used throughout this article.

The elderly population in RACF represents a wide spectrum of clinical disability. The majority of these individuals are vulnerable to infections due to frailty, poor functional status, multiple comorbidities, and compromised immune systems.[3–5] Bed-bound residents are generally at greater risk of skin infections,[6] while those with urine and fecal incontinence have an increased risk of urinary tract infections.[5] In addition, close living proximity and frequent nurse–resident contact facilitate the spread of organisms among RACF residents.[3] This condition, coupled with the to and fro nature between RACF and acute hospital setting, promotes a higher infection burden among residents in RACF compared to community dwellers.[7,8]

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Although the infection burden among the RACF population has long been recognized, infection prevention efforts are often limited to infection surveillance activity. Of concern is the widespread antibiotic prescribing in RACFs, which may lead to the emergence of antibiotic resistance. Studies have reported an increasing use of broad-spectrum oral antibiotics, such as quinolones, among this population, with up to 75% of use judged to be inappropriate.[9,10] In an era where multidrug-resistant (MDR) organisms are emerging in the community, RACF residents have been increasingly identified as important reservoirs for this development.[11,12] This trend highlights an immediate need to promote judicious antibiotic use in this population. However, unlike the acute care hospital setting, there are major practical challenges for implementing more targeted infection control and antimicrobial stewardship (AMS) strategies within this resource-limited environment.[13]

This review focuses on issues about inappropriate antibiotic use and the unique role of AMS in the RACF setting, with particular focus on comparisons between the US and Australasian settings. Additionally, it will also cover the epidemiology of health care-associated infections, trends of various MDR organisms, experiences of AMS interventions in the RACF setting, and future directions or recommendations for efforts to optimize antibiotic use.

Surveillance of health care-associated infections in RACFs

An effective infection surveillance system serves as a useful tool to help reduce health care-associated infections.[14] Health care-associated infection rates in RACFs have been widely reported using either single-day point prevalence surveys or long-term surveillance studies, with prevalence rates between 2.8%–16.2%,[6,15–24] and incidence rates ranging from 1.8–9.5 infections per 1,000 resident-care days reported worldwide.[25–34] However, a direct comparison of infection rates across wide geographical areas is not practical, partly due to differences in infection surveillance methodologies.

A European, multinational approach to infection surveillance, known as "Healthcare-Associated Infection in European Long-Term Care Facilities" (HALT) was introduced in 2008.[13] This surveillance activity aimed to provide a tool for the assessment of infection burden, which was used to guide European RACFs infection prevention and control programs. Similarly, in the US, a mandatory requirement for all RACFs to maintain regular documentation of recent infections allows for the ongoing surveillance of infection data;[35] such large-scale surveillance activity remains scant in other countries.

An effective infection surveillance system requires valid uniform definitions for various infectious syndromes to allow for interfacility comparisons. Residential care-specific surveillance criteria for defining infections, known as the McGeer criteria, were originally developed by a Canadian consensus group in 1991.[36] Although several criticisms were raised to challenge the validity of these definitions,[37,38] the McGeer criteria remained the most widely used infection definitions for surveillance purposes in the RACF setting worldwide.[39] Recently, the McGeer criteria were revised in an effort to establish more evidence-based criteria, with a focus on preventable infections.[40] However, the feasibility of the revised criteria, which require laboratory confirmation for the diagnosis of respiratory and urinary tract infections, warrants further research.

Despite the wide variation of the incidence or prevalence rates reported in the literature, the three most frequently reported infections in RACFs are urinary tract infections (UTIs), respiratory tract infections (RTIs), and skin and soft tissue infections.[6,16,18,24,28,29,34] Several studies have reported that UTIs and RTIs were also the most commonly observed causes for hospital admissions among the elderly from RACFs.[7,41,42] Common occurrences of infectious syndromes in the absence of on-site diagnostic facilities or timely expert support have been reported to result in the frequent transfer of RACF residents to acute care hospitals.[43] Besides incurring higher health care costs, frequent resident referrals to hospitals were shown to be associated with poorer clinical outcomes.[44,45] Consequently, there has been a preference in promoting the management of infections within RACFs to avert hospital admissions. This, however, raises other practical issues, particularly the availability of infectious disease expertise and support to provide reasonable standards of infection management in the RACFs.

Epidemiology of multidrug-resistant organisms in the RACF setting

The RACF population has been increasingly recognized as an important reservoir for the transmission of MDR organisms in the community.[46,47] Several studies have reported that this population is at high risk for carrying MDR organisms, with such patients warranting broad-spectrum empiric antibiotic therapy upon hospital admission.[11,12]

Traditionally, methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant *Enterococci* (VRE) were recognized as common culprits causing various health

care-associated infections in the RACF setting.[1] Thus, infection control strategies have focused largely on preventing the transmission of these organisms among RACF residents.[1,48] However, in recent years, there has been an emerging trend of MDR gram-negative *Bacilli* (GNB) seen among this population. Based on studies exploring the carriage of three major groups of MDR organisms (ie, MRSA, VRE, and MDR GNB), there appears to be a shift in the epidemiology of MDR organisms in the RACF over the last decades.[49] Indeed, studies conducted in the 1990s and early 2000s have demonstrated that MDR GNB colonization was less commonly found in comparison to MRSA and VRE.[50–52] On the contrary, studies conducted in the late 2000s have shown an emergence of MDR GNB, with some studies reporting colonization rates far exceeding that of MRSA and VRE.[47,53,54] The emergence of MDR GNB is not limited to the asymptomatic carriage of these organisms. O'Fallon et al[46] examined 1,661 clinical cultures to compare the presence of MRSA, VRE, and MDR GNB over a 2-year period. The authors noted that MDR GNB (11%) were isolated more frequently than MRSA (6%) or VRE (1%), and that there appeared to be a steady rise in MDR GNB isolates.[46]

In view of existing infection control guidelines mainly addressing MDR gram-positive organisms (ie, MRSA and VRE), a shift of attention in infection control strategies that focus on the emergence of MDR GNB among RACF residents is warranted. Furthermore, the increasing trend of MDR GNB infections poses significant challenges to the existing option for antibiotic therapy, given the limited number of MDR GNB active antibiotics currently available or in development.[55] Fundamentally, awareness about this shift in trends is important, first as it informs the potential change of empiric antibiotic treatment among this high-risk population, and second, it encourages that microbiological investigations guide appropriate antibiotic use.

Prior exposure to antibiotics appears as one of the most prominent risk factors associated with colonization and infection of both MDR gram-positive and gram-negative organisms.[53,54,56–60] Specific antibiotics most frequently associated with MDR organisms include fluoroquinolones[60–66] and trimethoprim-sulfamethoxazole.[60,67] Indeed, several studies have highlighted that inappropriate and excessive use of antimicrobials has led to the development of antimicrobial resistance in the long-term care setting.[60,61,68–71] In comparison to other age-related risk factors, such as the presence of wound or pressure ulcers and reduced functionality (which are not modifiable to any great extent), reducing unnecessary or widespread use of antibiotics might be a more straightforward and critical strategy to curb the rapid emergence of MDR organisms.

Global snapshot of antibiotic use in RACFs

Inevitably, rising infection burden predisposes an individual to increased antibiotic prescription, and this high burden of antibiotic use in RACFs has been evident in numerous studies.[72–77] It has been reported that exposure to at least one course of antimicrobials occurs in 50%–80% of RACF residents annually.[72–77] In the US, antimicrobial agents have been shown to be among the most frequently prescribed medications in RACFs, accounting for almost 40% of all the systemic drugs prescribed,[78] with more than one in ten residents receiving an antimicrobial at any given time.[9] There is a wide variation in the reported antimicrobial use patterns in RACFs, as summarized in Table 1.

A cross-national surveillance on antimicrobial prescribing in nursing homes across 15 European countries demonstrated dramatic differences in antibiotic use (in defined daily doses/1,000 residents/day), ranging from 5.9 in Germany to 135.7 in northern Ireland in the first survey, and from 15.3 in Latvia to 121.9 in Italy in the second survey 7 months later.[83] The reasons for the observed variations in antibiotic use patterns are multifactorial, and include factors associated with the resident (resident and clinical characteristics, infection burden) and the facility (size of the RACFs, institutional antibiotic policy). Interestingly, a population-based study involving 363 RACFs in Canada showed that variations in antibiotic prescribing did not appear to be driven by resident- or facility-associated factors; instead, it was influenced by the prescriber's preference.[72,81] These findings suggest that interventions to improve antibiotic use should include influencing the antibiotic prescribing behavior of the prescribers.

The most commonly prescribed antibiotics in RACFs (Table 1) vary across different countries, with patterns more comparable in studies conducted within the same country.[24,34,85] The prescribing patterns are influenced by national and regional antibiotic guidelines. For instance, the US and Canadian RACFs commonly report significant use of quinolones,[9,72] while other countries such as Australia show lower use of these antimicrobials.[34] Likewise, the use of intravenous (IV) antibiotics is influenced by the policy or health care model of the individual RACFs. Some facilities report that 7%–9% of antimicrobials are given parenterally,[60,88] while others claim a $<1\%$ usage of IV therapy.[20,86] In a cross-sectional study involving 21 European countries, the proportions of parenteral antibiotics differed considerably

Table 1 Studies describing antibiotic prescribing patterns in RACF across different countries

Authors (country, year of surveillance, study size)	Rates of antibiotic use; most common antibiotics	Issues of concern highlighted in the study
Point prevalence survey – prevalence: (residents receiving ≥1 antibiotic)/(all residents)		
Zimmer et al[79] (US, 1983, 42 RACFs)	Prevalence: 173/2,238 (8%); trimethoprim/sulfamethoxazole (43%) ampicillin or amoxicillin (19%), nitrofurantoin (8%)	Evidence to initiate the antibiotic was judged as adequate in 62% of cases based on an expert panel. Main concern is high proportion of empiric antibiotic therapy without prior investigation.
Pakyz and Dwyer[9] (US, 2004, 1174 RACFs)	Prevalence: 161,599/1,330,608 (11%); nitrofurantoin (12%), levofloxacin (12%), and ciprofloxacin (7%)	No assessment on the appropriateness of antibiotic use.
Moro et al[22] (Italy, 2007, 49 RACFs)	Prevalence: 234/1,926 (12%); most common antibiotics not specified	27 of 122 patients (22%) receiving systemic antimicrobials with reason for antibiotic therapy not clear.
Latour et al[80] (21 European countries, 2009, 323 RACFs)	Prevalence: 1,966/32,685 (6%); β-lactam penicillins (29%), quinolones (14%), other beta-lactam antibiotics (11%)	Empirical treatments were most common (54% of all antibiotic use), followed by prophylactic (29%) and microbiologically documented treatments (16%).
Daneman et al[81] (Canada, 2009, 363 RACFs)	Prevalence: 2,190/37,371 (6%); nitrofurantoin (15%), trimethoprim/sulfamethoxazole (14%), and ciprofloxacin (13%)	Treatment courses were at least 10 days in duration (63%), and many exceeded 90 days (21%), suggesting chronic prophylaxis.
Rummukainen et al[82] (Finland, 2009, nine RACFs)	Prevalence: 716/5,691 (13%); methenamine (41%), trimethoprim (14%), and pivmecillinam (11%)	The prophylaxis of UTIs was the most common indication for antibiotic use.
McClean et al[83] (15 European countries, 2009, 85 RACFs)	Prevalence of two surveys: 6.5% in April/5.0% in November; methenamine (18%), trimethoprim (11%), and co-amoxiclav (11%) in April and co-amoxiclav (12%), nitrofurantoin (12%) and methenamine (12%) in November	No assessment on the appropriateness of antibiotic use.
Cotter et al[16] (Ireland, 2010, 69 RACFs)	Prevalence: 426/4,170 (10%); most common antibiotics not specified	Up to 40% of total prescriptions were for prophylactic indications. Only 57% of residents prescribed antibiotics for UTI had a microbiological investigation.
Moro et al[23] (Italy, 2010, 92 RACFs)	Prevalence: 438/9,285 (5%); quinolones (24%), penicillin plus beta-lactamase inhibitor (22%), and third-generation cephalosporins (21%)	Only 49% treatment given for McGeer modified confirmed infection, 30% nonconfirmed infection, and 21% no documented infection.
McClean et al[84] (Ireland, 2010–2011, 30 RACFs)	Prevalence: 9% systemic antibiotic, 6% topical antibiotic; trimethoprim, cephalexin, and nitrofurantoin were most commonly prescribed	High use of topical antimicrobial for prolonged duration. Based on antibiotic guidelines, almost 25% of systemic antibiotics were prescribed at inappropriate doses.
Stuart et al[85] (Australia, 2011, five RACFs)	Prevalence: 23/257 (9%); doxycycline (26%), cephalexin (17%) and flucloxacillin (13%), or trimethoprim (13%)	A total 26% of antibiotic use was given for prophylactic reasons. Up to 40% did not fulfill the McGeer criteria for bacterial infection.
Smith et al[24] (Australia, 2011, 29 RACFs)	Prevalence: 63/757 (8%); cephalexin (33%), amoxicillin, trimethoprim, and nitrofurantoin (10% each)	Up to 39% of total prescriptions were for prophylactic indications.
Heudorf et al[20] (German, 2011, 40 RACFs)	Prevalence: 90/3,732 (2%); quinolones (n=31), cephalosporins (n=19), penicillins (n=11), and co-trimethoprim/sulfamethoxazole (n=11)	Empiric prescribing without microbiological investigation for UTIs (92% of antibiotic treatment)
Longitudinal surveillance – incidence: (number of antibiotic courses)/(100 patient-days)		
Mylotte[75] (US, 1989, single RACF)	111/156 (71%) received ≥1 incident course a year Incidence: 0.61 antibiotic course/100 patient-days; trimethoprim/sulfamethoxazole (29%), ciprofloxacin (26%), amoxycillin (12%)	Questionable high use of fluoroquinolones as empiric therapy.
Warren et al[77] (US, 1991, 53 RACFs)	2,105/3,899 (54%) received ≥1 incident course a year Incidence: 0.46 antibiotic course/100 patient-days; beta-lactam antibiotics (54%) most common	>50% of antibiotic courses started without documented investigation. Treatments were initiated for "viral" upper respiratory infections (13%) and asymptomatic bacteriuria (9%)
Loeb et al[74] (Canada, 1996, 22 RACFs)	2,408/3,656 (66%) received ≥1 incident course a year Incidence: 0.73 antibiotic course/100 patient-days; trimethoprim–sulphamethoxazole, (17%) ciprofloxacin (17%), amoxicillin (13%)	McGeer criteria were only met in 49% of patients prescribed antibiotics; 30% of antibiotic prescriptions for urinary indication were for asymptomatic bacteriuria.
Blix et al[86] (Norway, 2003, 133 RACFs)	Incidence: range 4–44 DDD/100 patient-days; penicillins with extended spectrum, followed by trimethoprim and sulfonamides	High use of a urinary prophylactic agent, methenamine, represented nearly half (46%) of DDDs used.

(*Continued*)

Table 1 (*Continued*)

Authors (country, year, study size)	Rates of antibiotic use; most common antibiotics	Issues of concern highlighted in the study
Pettersson et al[87] (Sweden, 2003, 58 RACFs)	Incidence: one treatment/resident/year; penicillins (38%), followed by quinolones (23%) and trimethoprim (18%)	Based on national guidelines, 50% of lower UTIs in women were not treated according to the recommendations (questionable length of treatment and overprescribing of quinolones).
Lim et al[34] (Australia, 2010, four RACFs)	Incidence: 0.71 antibiotic course/100 patient-days; cephalexin (25%), trimethoprim (14%), amoxycillin–clavulanate (13%)	Up to 37% did not fulfill the McGeer criteria for bacterial infection. Antimicrobials were routinely prescribed for URTI and acute bronchitis (31%), also common for asymptomatic bacteriuria.
Daneman et al[72] (Canada, 2010, 630 RACFs)	50,061/66,901 (75%) received ≥1 incident course a year; second-generation fluoroquinolones (19%), penicillins (17%), third-generation fluoroquinolones (17%)	Prolonged treatment courses were common for all antibiotic subclasses, with 45% that exceeded a 7-day course.

Abbreviations: RACFs, residential aged care facilities; UTI, urinary tract infection; n, number; DDD, defined daily dose; URTI, upper respiratory tract infection.

between and within countries (range: 0%–67%).[88] Parenteral antibiotics were most commonly prescribed for pneumonia, with one study reporting that more than half of the prescribed antibiotics for suspected pneumonia were administered parenterally.[89]

Assessing the appropriateness of antibiotic use

Studies examining antibiotic prescribing practices vary in a number of ways, particularly with regard to the standard that is used for judging the antibiotic's appropriateness. To date, the evidence on which to base definitive recommendations for antibiotic use in the RACF setting is lacking. There are several published clinical practice guidelines available to assist the diagnostic evaluation process[90,91] and empiric antibiotic prescribing decisions[78,92] in the RACF setting. These guidelines account for the barriers and difficulties specific to this resource-limited setting, but they are tailored for the US long-term care setting. For instance, Nicolle et al[78] have recommended quinolones and IV aminoglycoside as first-line empirical antibiotic treatments for UTIs. The applicability of these guidelines outside the US system remains unknown, and reports on adherence to these guidelines are rare. A recent study involving 12 RACFs in North Carolina has shown that only 13% of antibiotic prescriptions were classified as adherent to the Loeb minimum criteria, a consensus standard for the initiation of empiric antibiotics among residents of RACFs.[92,93]

Previous studies have applied various approaches or definitions to assess the "appropriateness" of antibiotics prescribed in RACFs. These include the use of an "expert panel",[79,94] validation according to the McGeer criteria,[22,34,74,85] and concordance with published antibiotic guidelines.[84,87,95] Regardless of the differences in criteria used for judging appropriateness, 40%–75% of antibiotic use has been claimed to be inappropriate.[10,22,74,79,85,87,94] The McGeer criteria were developed for the purpose of establishing surveillance definitions rather than to assist in clinical decision making. Thus, they should be considered as conservative guidelines for assessing antibiotic use, and the data pertaining to "inappropriate" antibiotic use based on these criteria should be interpreted with caution.

Areas of potential antibiotic misuse

To assist the development of evidence-based antibiotic prescribing practices applicable in the RACF setting, it is essential to identify areas of potential antibiotic misuse specific to this setting. Major issues of potential antibiotic misuse among this population that warrant further investigations and improvements have been highlighted in Table 1. These issues are highlighted as follows:

1. Prophylactic antibiotic for UTI.[16,24,82,86] Evidence on the effectiveness of this strategy among institutionalized elderly patients in RACF remains scant. Prolonged antibiotic use in the absence of infection inevitably selects for resistant organisms. A study by Blix et al[86] showed that methenamine, a urinary prophylactic agent, represented nearly half of the defined daily doses used. The high use of this agent is problematic, with inconclusive evidence to support its use for long-term urinary prophylaxis in the latest Cochrane Review.[96]
2. Empiric prescribing without microbiological investigation.[20,77,79,80] Studies have reported that only about 15% of antibiotic treatment was given empirically without microbiological investigation.[20,80] Inappropriate antibiotic use is associated with worse clinical outcomes and, in some cases, increased mortality.[97] Therefore, causative etiologic agents should be identified, especially in symptomatic UTIs, to guide the adjustment of empiric antibiotic therapy.

3. Treatment of asymptomatic bacteriuria.[34,74,77] There is compelling evidence from several randomized controlled trials that strongly support not treating asymptomatic bacteriuria in institutionalized elderly patients, given the lack of treatment benefit,[98–100] and the patients' association with the emergence of antibiotic resistance.[101] Asymptomatic bacteriuria is particularly prevalent among RACF residents with chronic indwelling urethral catheters, and antibiotic therapy will not prevent recurrent bacteriuria or symptomatic infections.[102] Nearly all chronically catheterized patients are bacteriuric;[103] therefore, the indwelling catheter should be changed prior to the initiation of antibiotic and a urine specimen should be collected from the newly placed catheter. Discontinuation of catheter use and proper aseptic techniques in catheter changing are the keys to preventing UTIs or other urinary complications.
4. Widespread prescribing for upper RTIs or acute bronchitis.[34,77,104] Among the institutionalized elderly, upper RTIs are usually caused by viral pathogens, where empiric antibiotic treatment is seldom necessary, unless these patients have prolonged symptoms, or preexisting underlying lung diseases.[78] An effort to differentiate between viral or bacterial origins of presumed RTIs is critical to reduce the inappropriate use of antibiotics. Fundamentally, a minimum set of criteria regarding patient assessment and investigation should be followed prior to making decisions about empirical antibiotic therapy.[78]
5. Prolonged duration of antibiotic treatment.[72,81,84] There is evidence that antibiotic courses of 7 days or less are as effective as longer treatment durations for the majority of common bacterial infections.[105,106] On the contrary, unnecessarily prolonged antibiotic treatment will increase a patient's risks of side effects and antibiotic resistance.
6. Widespread prescribing of quinolones as empiric treatment for UTIs.[10,75,87] Excessive use of these agents is mainly due to their excellent bioavailability, long half-life, and broad-spectrum properties that are ideally suited for the treatment of lower RTI, as well as complicated UTI.[107,108] Consequently, a high rate of quinolone-resistant gram-negative organisms has been frequently observed in the RACF setting with a high use of quinolones.[109–111]
7. Broad-spectrum or parenteral antibiotic treatment for elderly individuals with advanced dementia or end-stage illness.[89,112] Several studies have shown that antibiotics may be considered futile (ie, they do not prolong survival or reduce discomfort) at the end stages of life,[113,114] whereas other studies show contradictory results.[115,116] In view of the inconclusive evidence, aggressive antibiotic treatment for pneumonia among RACF residents with advanced dementia warrants further investigation and guidance.

Evolving role of the antimicrobial stewardship (AMS) program in RACFs

AMS programs are integrated activities that help to optimize antimicrobial therapy, ensuring the best clinical outcomes while minimizing the risk of the emergence of antibiotic resistance.[117] As antibiotic resistance increases and new antibiotic development declines, using existing antibiotics more wisely through AMS programs is an immediate and critical measure that can be used to address this public health crisis. AMS has been increasingly established in the acute care hospital setting, but it remains a relatively new concept in the RACF setting.[118]

In addition to its positive impact on curbing the emergence of antimicrobial resistance, there are other incentives to initiate AMS programs in the RACF setting. The elderly populations in RACFs are generally more susceptible to adverse drug reactions and drug–drug interactions due to their decreased physiological function, comorbidity, and polypharmacy.[4] Repeated antimicrobial courses, especially the use of broad-spectrum antibiotics, will increase the risk of *Clostridium difficile* infection. In addition, the elderly populations in RACFs have been shown to be at higher risk for acquiring toxigenic *C. difficile*.[119] Clearly, an effort to reduce inappropriate or unnecessary use of antibiotics via effective AMS interventions is warranted in this high-risk population to prevent adverse consequences associated with inappropriate antibiotic use, as well as to reduce health care costs.

An international guideline on AMS was jointly published by the Infectious Diseases Society of America and the Society for Healthcare Epidemiology of America in 2007;[120] however, this guideline was based primarily on the acute care hospital setting. International guidelines for infection control and prevention in the long-term care setting have recommended the initiation of AMS programs in this setting,[1,2] although recommendations about feasible AMS interventions specific to this low-resource setting have not been clearly outlined. These guidelines only recommend a minimum standard of monitoring for antimicrobial use and local antimicrobial susceptibilities, while providing routine feedback to relevant authorities.[1,2] Therefore, specific guidelines on AMS programs targeting the RACF setting remain to be developed.

Challenges and barriers for implementation of AMS in RACFs

Several important factors that potentially contribute to widespread and inappropriate antibiotic use among this population have been previously highlighted (see Areas of potential antibiotic misuse). The clinical diagnosis of infectious syndromes among elderly RACF residents is challenging due, in part, to the residents' atypical clinical presentation. The most common symptoms of infection among elderly residents are nonspecific manifestations such as delirium, falls, functional decline, and breakdown of social supports.[121] Fever was absent or blunted in 20%–30% of well-documented severe infections in the elderly population.[4] Atypical presentations can potentially lead to delayed diagnosis, late initiation of empiric antimicrobial therapy, and poorer clinical outcomes.[5] On the other hand, early therapy initiation is often preferred "in case" residents deteriorate,[122] which has led to antibiotic initiation without confirmed infection. Difficulties in initiating investigations among RACF residents, especially those with cognitive impairment, further complicate the clinical decision-making process.[78] Midstream urine cultures are almost impossible to obtain from this patient population, especially in the presence of urinary incontinence; this further leads to a lack of microbiological data through which to guide antibiotic treatment.

In the RACF setting, all aspects of resident care, including infection management, are largely driven by nursing staff.[123] The elderly residents in RACFs have less physician contact compared to hospitalized patients, rendering infection management difficult and mostly driven by nurses or telephone assessment by off-site physicians.[124] A study by Warren et al[77] reported that 31% of residents with severe infections were not noted to have been examined by a physician. Additionally, in a study exploring the process involved in the management of UTIs in RACFs, general practitioners claimed that they seldom visit their patients for a UTI, and they indicated that they relied mostly on the nursing staff's assessments.[123] Nonetheless, the ability and knowledge of nursing staff to drive infection management remain largely unexplored. Importantly, staffing issues such as rapid staff turnover and low nurse–resident ratios have been previously identified as one of the contributors for higher infection burden among RACF residents.[125] Furthermore, limited access to infectious diseases specialists, on-site pharmacists, and infection control nurse consultants render the overseeing of antibiotic prescribing difficult, posing additional barriers to the implementation of AMS programs in the RACF setting.

The lack of on-site pathology and radiology support further complicates antibiotic prescribing decisions.[126] For example, it is generally recommended in the hospital that chest radiograph, pulse oximetry, complete blood count with differential, and blood urea nitrogen be obtained in residents with suspected chest infection, especially in cases of pneumonia. Nonetheless, antibiotic treatment for chest infections in RACFs is almost exclusively empirical because diagnostic investigations to define the etiology are infrequently performed.[73,79] A comprehensive review by Nicolle et al[78] has suggested several potential challenges, including the lack of institutional antibiotic policy or published guidelines specific to the RACFs, and limited access to infectious disease experts. All of these factors might hinder appropriate monitoring and stewardship of antibiotic use in this setting.

A cross-national survey in 2006 found significant gaps in infection prevention preparedness in RACFs in many European countries, including the lack of governance structures, inadequate national RACF-specific guidelines or policies, lack of awareness, and major gaps in infection prevention and control expertise.[13] Similar efforts to identify modifiable factors that influence antibiotic prescribing behavior in the RACF setting is essential to guide further improvement of antibiotic use. Understanding the barriers and facilitators within existing organizational systems is a fundamental step that is needed prior to the introduction of AMS interventions in individual RACFs.

AMS activities in the RACF setting

The availability and structure of AMS activities in RACFs across different countries are variable. A national survey reported limited AMS activities in the Irish RACF setting.[127] In contrast, a survey in Nebraska revealed that more than half of participating RACFs reported to have established AMS programs, some with high-intensity interventions such as preauthorization and audit/feedback of antibiotic use.[128] This survey, which had large participation from RACFs in the rural setting, showed that AMS programs are not limited to hospital-affiliated RACFs or urban areas, but they have become increasingly prevalent across the state. Several studies have reported the outcomes of various strategies for antibiotic use optimization (ie, AMS) in the RACF setting (Table 2).

The studies to date are largely from the US and Canada, with a paucity of data about AMS initiatives in RACF settings in other countries. Extrapolation of data between different countries may not be feasible in view of the variation

Table 2 Types, areas, and outcomes of AMS strategies in the RACF

Authors (country, year, study size)	Types of interventions	Areas targeted	Study outcomes	Study limitations
Naughton et al[129] (US, 2001, ten RACFs)	Multifaceted education intervention involving physicians, nurse practitioners, and nursing staff	Consensus antibiotic treatment guidelines for nursing home-acquired pneumonia	Significant increase in the use of parenteral antibiotics in accordance with guidelines, but did not alter oral antibiotic use, hospitalization, or 30-day mortality.	Sample size was too small to determine the impact of the intervention on hospitalization and mortality.
Loeb et al[130] (Canada and US, 2005, 24 RACFs)	Multifaceted approach targeting nurses, and interviews with physicians	Diagnostic and treatment algorithm for UTIs	Rates of antimicrobial use for suspected UTI was significantly lower in the intervention than usual care group.	No significant difference found in total antimicrobial use (when accounting for other infections). The effect of the intervention reduced over time.
Hutt et al[131] (US, 2006, two RACFs)	Multifaceted approach involving institutional-level change of antibiotic policy, and educational sessions for nurses and physicians	Evidence-based guidelines for treating nursing home-acquired pneumonia	The compliance with the guidelines improved, including the use of appropriate antibiotics, and timely antibiotic initiation at the intervention facility.	The intervention was brief (over one influenza season) and limited to one intervention facility.
Schwartz et al[132] (US, 2007, single RACF)	National guidelines, hospital resistance data, and physician feedback were incorporated into a series of four teaching sessions and into booklets	Optimal treatment for common long-term care infection syndromes	Antimicrobial use decreased significantly during the intervention period; both decreases were sustained during the 2-year postintervention period.	The intervention was tailored specifically for hospital-based RACF with on-site pathology and radiology supports.
Monette et al[133] (Canada, 2007, eight RACFs)	Educational intervention comprising of mailing an antibiotic guide to physicians with individual antibiotic prescribing profiles in previous 3 months	Targeted infections were UTIs, RTIs, SSTIs, and septicemia of unknown origin	Nonadherent antibiotic prescriptions decreased by 20.5% in the experimental group, compared with 5.1% in the control group.	Did not address the effect of clustering on the sample size, which undermines the ability to adequately detect changes in the outcome measures.
Zabarsky et al[134] (US, 2008, single RACF)	Education of nursing staff and primary care practitioners by the infection control nurse	Optimal management of asymptomatic bacteriuria	Inappropriate submission of urine cultures, overall rate of treatment of asymptomatic bacteriuria, and total antimicrobial days of therapy were reduced significantly.	Study was carried out in a single RACF with availability of full-time primary care practitioners, thus the result may not be applicable to RACF without this support.
Pettersson et al[135] (Swedan, 2011, 58 RACFs)	Small educational group sessions with nurses and physicians	Guidelines for management of lower UTI, targeted at reducing use of quinolones	Modest effect shown; proportion of quinolones decreased significantly in both intervention and control groups, but no difference found between the two groups.	The intervention had a modest effect. The reduction in proportion of quinolones cannot be attributed to the intervention.
Linnebur et al[136] (US, 2011, 16 RACFs)	Educational sessions for nurses and academic detailing to general practitioners by pharmacists	National NHAP treatment guidelines	Increased adherence to guidelines about timely administration of antibiotics to NHAP episodes, but not adherence regarding the optimal duration and selection of antibiotic.	Effect of an intervention toward antibiotic choice and length of therapy was not seen, largely due to insufficient time allocated for academic detailing and limited interaction with the prescribers.
Gugkaeva and Franson[137] (US, 2012, single RACF)	A pharmacist-led AMS program consists of a prospective audit and interventions, with onsite pharmacist support	Optimal treatment for common long-term care infection syndromes	Significant reduction in inappropriate prescribing of antibiotics was seen within the first 3 months after implementation with good acceptance by prescribers.	The study was limited to a single RACF, and the sustainability of this intervention (ie, a 3-month trial) was not assessed.
Jump et al[138] (US, 2012, single RACF)	Infectious disease consultation service that provides on-site consultations to residents; the service team consisted of an infectious disease physician and a nurse practitioner	Optimal treatment for common long-term care infection syndromes	Total systemic antibiotic (both oral and intravenous) administration decreased significantly by 30%. The rate of positive *C. difficile* tests declined after the intervention.	This model is labor-intensive and may not be applicable to RACF without sufficient infectious disease supports.

Abbreviations: AMS, antimicrobial stewardship; RACF, residential aged care facilities; UTI, urinary tract infection; RTI, respiratory tract infection; SSTI, skin and soft tissue infection; NHAP, nursing home-acquired pneumonia.

in antibiotic prescribing patterns between countries. For instance, while two US studies used strategies to reduce the high use of fluoroquinolones or IV antibiotics,[131,138] this may not necessarily be an issue in RACF settings that demonstrate minimal use of fluoroquinolones or IV antibiotics.

International guidelines on AMS have identified two core proactive strategies for promoting AMS in hospital settings.[120] The first core strategy refer to formulary restriction and/or a requirement for preapproval for administration of specific drugs (front-end approach), and the second is prospective audit that offers an intervention and feedback to prescribers (this is either a front-end or a back-end approach). Other supplemental strategies include educating prescribers, implementing evidence-based guidelines, engaging in an IV-to-oral route switch, de-escalation, dose optimization, or antibiotic cycling, and using computer decision support systems.

There are major differences in AMS interventions between RACF and acute care settings. The types of AMS interventions in the RACF setting have mainly focused on supplementary strategies such as educational interventions or the introduction of antibiotic treatment algorithms and guidelines (Table 2). More proactive hospital-based AMS interventions are limited. Two recent studies have described pharmacist-led or infectious diseases expertise consultation in their AMS models; however, both studies were carried out at hospital-affiliated and Veterans Affairs long-term care facilities with the on-site support of relevant health care professionals.[137,138] In the US, higher expert support was more commonly available in the Veterans Affairs affiliated facilities than in the generic nursing homes.[138,139] The feasibility of these labor-intensive AMS models in other RACF settings warrants further investigation. Additionally, AMS interventions in hospitals generally focus on reducing high costs or broad-spectrum antibiotics, and they encourage IV-to-oral conversions.[140] Conversely, in the RACF setting, the focus lies on promoting appropriate antibiotic use for specific types of common infections (for example, pneumonia and UTIs) or adherence to evidence-based guidelines.

Overall, the studies outlined in Table 2 have shown at least one positive effect on antibiotic prescribing, reflecting the value of AMS initiatives in the RACF setting in improving antibiotic prescribing practices. However, a systematic review has highlighted several methodological limitations of four studies,[129,130,133,135] which are outlined in Table 2, and no definitive conclusion can be reached about the positive effect of particular AMS interventions.[141] Additionally, there are major practical challenges to developing a sustainable and effective model of AMS in the RACF setting. Loeb et al[130] highlighted a decreased effect of interventions in the months following intervention implementation, reflecting the limited sustainability of an AMS program in the participating facilities.[130] A stepwise approach to AMS implementation in RACF settings was proposed by Smith et al,[118] who suggested that AMS initiatives should commence with the least costly and intrusive approach, with more advanced measures added incrementally based on available resources and institutional needs. Therefore, identifying the limitations of organizational cultures and resources in individual RACF settings is important to inform the development of an AMS program.

Conclusion

Although antibiotic misuse is problematic in all health care settings, the RACF setting has a particular set of issues that makes any AMS program challenging. RACFs cater to a vulnerable elderly population who have been shown to be at greater risk for acquiring MDR organisms. Increasing evidence proposes that RACF residents serve as an important reservoir for MDR organism transmission, including the emergence of MDR gram-negative organisms. Importantly, prior exposure to antibiotics has been identified as one of the most prominent, yet amendable, risk factors for MDR organism acquisition in an RACF setting. There may have been a misconception that settings with lower resources (such as RACFs) are incapable of supporting AMS programs. Conversely, AMS programs should be viewed as a range of interventions that can be adapted and applied in any health care setting, including in RACF settings.

In an era characterized by a rapid emergence of MDR organisms, an AMS program should be increasingly appreciated across the continuum of care; this might even be more important in a setting that has fewer resources and supports, such as an RACF. While there are barriers to AMS activities in RACFs, activities that are tailored to the context and needs of an RACF setting have been shown to be useful and effective, highlighting the unique role of AMS in this setting. At minimum, an AMS program will require executive support, education capability, and means of monitoring and feeding back antibiotic use to prescribers. Essentially, educational interventions targeting nursing staff and physicians, as well as infection management algorithms and antibiotic treatment guidelines specific to the RACF setting will be critical to promote prudent antibiotic prescribing practices.

Disclosure

The authors report no conflicts of interest in this work.

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