

Prevalence of antimicrobial-resistant organisms in residential aged care facilities

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The prevention and control of transmission of antimicrobial-resistant pathogens in residential aged care facilities (RACFs) has significant implications for health services. Challenges include limited infection control resources, lack of robust prevalence data, and complexities of service provision and governance. Antimicrobial stewardship is difficult because of multiple service providers, lack of understanding of organism susceptibility, and desire to treat residents before they become seriously unwell.

Frequent antibiotic use and multiple hospital visits result in an increased risk of RACF residents acquiring vancomycin-resistant enterococci (VRE).¹ They are also at risk of *Clostridium difficile* infection, which may present with varying severity, from mild diarrhoea to pseudomembranous colitis, toxic megacolon or death. Since 2000, there has been an increase in the rates of *C. difficile* infection in health care facilities in the United States and Europe associated with an epidemic strain, PCR ribotype 027, characterised by increased toxin production and increased sporulation.^{2,3} This strain has recently been detected in Australia.^{4,5}

The emergence of multiresistant gram-negative bacteria (with resistance to three or more different antimicrobial classes) is a major public health concern. Recent studies show that outcomes of multiresistant gram-negative bacteria infections are worse than those caused by susceptible organisms, and that RACF residents may be a source of transmission in the acute hospital setting.^{6–9} Extended-spectrum β -lactamases (ESBLs) are capable of conferring bacterial resistance to all β -lactam antibiotics except cephamycins (eg, cefoxitin) and carbapenems (eg, meropenem).¹⁰ Patients at high risk of colonisation or infection with ESBL-producing organisms are often those who are seriously ill, with prolonged hospital stays and with invasive medical devices in place. Other risk factors include total parenteral nutrition, recent surgery or hospitalisation, haemodialysis, pressure ulcers, age

Abstract

Objective: To assess the frequency of, and risk factors for, colonisation with vancomycin-resistant enterococci (VRE), *Clostridium difficile* and extended-spectrum β -lactamase (ESBL)-producing organisms in residential aged care facilities (RACFs).

Design, setting and participants: We conducted a point prevalence survey in October – November 2010 in three RACFs associated with our health service. A single faecal sample was collected from each participating resident and screened for the presence of VRE, *C. difficile* and ESBL-producing organisms. Presence of risk factors for antibiotic-resistant organisms was identified using a questionnaire.

Main outcome measures: Prevalence of colonisation with VRE, *C. difficile* and ESBL-producing organisms; molecular typing of ESBL-producing organisms; prevalence of risk factors including presence of a urinary catheter, recent inpatient stay in an acute care setting and recent antibiotic consumption.

Results: Of 164 residents in the three facilities, 119 (73%) were screened. Mean age of screened residents was 79.2 years, and 61% were women; 74% had resided in the RACF for >12 months, 21% had been given antibiotics within the past month and 12% had been in an acute care centre within the past 3 months. Overall rates of VRE (2%) and *C. difficile* (1%) colonisation were low, but ESBL-producing *Escherichia coli* was detected in 14 residents (12%) overall, with half of these residing in one wing of an RACF (27% of wing residents tested). Ten of the 14 ESBL-producing isolates had identical molecular typing patterns and belonged to genotype CTX-M-9. Eight of 13 residents had persistent colonisation on repeat testing 3 months later.

Conclusion: We found a high prevalence of multiresistant ESBL-producing *E. coli* in RACF residents. A clonal relatedness of isolates suggests possible transmission within the facility. RACFs should have programs emphasising processes that will limit spread of these organisms, namely good hand hygiene compliance, enhanced environmental cleaning and dedicated antimicrobial stewardship programs.

≥ 65 years, dementia, diabetes, poor nutritional status, international travel (especially to Asia) and antibiotic use.^{11,12} Studies have found a relationship between third-generation cephalosporin (eg, ceftriaxone) use and acquisition of an ESBL-producing strain.^{13,14} Up to 20% of patients may have no identifiable risk factor.¹⁵ Perhaps the greatest risk factor for nosocomial acquisition is accommodation in a ward or room with patients with ESBL-producing organisms.¹⁶

We conducted a point prevalence survey to assess the frequency of, and risk factors for, colonisation with VRE, *C. difficile* and ESBL-producing organisms in three RACFs associated with our health service in Melbourne.

Methods

Study population

In October–November 2010, we assessed three facilities with a total of

164 beds. Facility A accommodates 100 residents requiring high-level care for activities of daily living and behaviour, and complex nursing, in single and double bedrooms with ensuites. The facility is divided into two wings (X and Y), with Wing X specialising in aged mental health care. Facility B (30 beds) also provides high-level care, and Facility C (34 beds) cares for residents requiring specialist mental health services (requiring low-level care for activities of daily living and behaviour).

Residents and/or their next of kin were informed of the study by mail and could opt out if desired. All data were de-identified. The study was approved by Southern Health Human Research Ethics Committee A as a quality assurance project.

Data collection

A single faecal sample was obtained from each participating resident's bedpan (or bed in cases of incontinence)

to be screened for VRE, ESBL-producing organism and *C. difficile*.

At the time of sample collection, nursing staff used a brief questionnaire to collect data on whether each resident had risk factors for antibiotic-resistant organisms, including the presence of a urinary catheter, being an inpatient in an acute care setting within the past 3 months, antibiotic consumption within the past month, and concurrent diarrhoea. Data were also collected on the resident's room placement within the facility.

Medical records for residents found to be colonised with ESBL-producing organisms were accessed to identify any recent clinical infections and to further characterise antibiotic consumption in the previous 6 months. The appropriateness of antibiotic prescribing in the RACFs was examined using data collected by infection control staff since July 2009 on residents prescribed enteral and/or parenteral antibiotics, and assessed using the well established definition proposed by McGeer and colleagues.¹⁷

In March 2011, we repeated screening on the residents with ESBL-producing organisms identified at the first screen to ascertain ongoing carriage rates.

Microbiological methods

To identify VRE, faecal specimens were cultured directly onto a chromID VRE medium (bioMérieux, Marcy-l'Étoile, France). After 24–48 hours of incubation, any purple (*Enterococcus faecium*) or blue (*Enterococcus faecalis*) colonies were subcultured onto a non-selective medium for simple biochemical testing, and isolates were confirmed as VRE by polymerase chain reaction (PCR) testing for *dll*, *van A*, *van B* and *van C* genes.^{18,19}

C. difficile testing was performed using a two-step algorithm. Samples were initially screened using the *C.DIFF CHEK - 60* enzyme immunoassay kit (TECHLAB, Blacksburg, Va, USA) to establish the presence of *C. difficile* by detecting glutamate dehydrogenase. Specimens testing positive were subsequently tested using the GeneXpert *C. difficile* assay (Cepheid, Sunnyvale, Calif, USA), which detects toxin B, binary toxin and the *tcdC* gene deletion associated with the PCR ribotype 027 epidemic strain.²⁰

Rates of colonisation with antimicrobial-resistant pathogens in three residential aged care facilities

Facility	No. of beds	No. (%) of residents tested	Number (%) of residents colonised		
			Vancomycin-resistant enterococci	<i>Clostridium difficile</i>	Extended-spectrum β -lactamase-producing organisms
A (Wing X)	40	26 (65%)	1 (4%)	0	7 (27%)
A (Wing Y)	60	42 (70%)	1 (2%)	0	4 (10%)
B	30	18 (60%)	0	1 (6%)	3 (17%)
C	34	33 (97%)	0	0	0
Total	164	119 (73%)	2 (2%)	1 (1%)	14 (12%)

ESBL-producing organisms were isolated from faecal samples using chromID ESBL medium (bioMérieux).²¹ After incubation for 24–48 hours, suspected ESBL-producing bacteria were identified to species level using the VITEK 2 GN identification card (bioMérieux). ESBL production was confirmed by the disc approximation (“keyhole”) test.²² Susceptibility testing was performed using the VITEK 2 N149 susceptibility card (bioMérieux). All ESBL-producing isolates underwent molecular typing using pulsed field gel electrophoresis using established criteria,²³ multiple-locus variant-repeat analysis²⁴ and characterisation of genes encoding for ESBL production.¹⁵

Statistical analysis

The outcome for the analyses was the presence or absence of colonisation with VRE, *C. difficile* or ESBL-producing organisms. Data were collected on a standardised form and analysed using Stata 8.2 (StataCorp, College Station, Tex, USA). Categorical variables were compared using the χ^2 test, and mean ages with the *t* test.

Results

Of the 164 residents, 119 (73%) were screened. The mean age of screened residents was 79.2 years (range, 43–102 years), and 73 (61%) were women. Eighty-eight screened residents (74%) had resided in the RACF for >12 months, 25 (21%) had been given antibiotics within the past month, 14 (12%) had been in an acute care centre within the past 3 months, and two (2%) had concurrent diarrhoea. Only five residents (4%), all from Facility A, had urinary catheters in situ (two indwelling and three suprapubic catheters).

The overall colonisation rates of VRE (*vanB E. faecium*) and *C. difficile* were low (2% and 1%, respectively),

but the rate of ESBL detection was 12% overall, ranging from zero to 27% of residents tested in some sites (Box).

All ESBL-producing isolates were *Escherichia coli*. The mean \pm SD age of residents colonised with ESBL-producing organisms was 83.7 \pm 7.3 years (range, 73–95 years), which was not statistically different from non-ESBL carriers (mean \pm SD, 79.1 \pm 10.7; range, 43–102 years; *P* = 0.12). There was no association between colonisation with ESBL-producing organisms and duration of residence in the RACF, antibiotic use within the previous month, hospitalisation within the previous 3 months, presence of diarrhoea, or urinary catheterisation.

ESBL carriage was strongly associated with facility — 27% of residents in Wing X of Facility A were colonised with ESBL-producing organisms, compared with only 10% in the adjoining Wing Y. The majority of residents in both wings were highly mobile within the wings (but not between them) and not confined to their rooms.

Typing of the 14 ESBL-producing isolates found that 10 were identical, including all seven isolates in Wing X of Facility A. All the ESBL-producing strains were CTX-M (cefotaxime-hydrolysing) producers, with 13 isolates containing the *bla*_{CTX-M-9} gene and one the *bla*_{CTX-M-15} gene.

In addition to β -lactam resistance, the predominant ESBL-producing strain was resistant to ciprofloxacin, norfloxacin, sulfamethoxazole and trimethoprim. The isolate with *bla*_{CTX-M-15} was also resistant to gentamicin.

Medical records from 12 of the 14 residents colonised with ESBL-producing organisms were available for review. Antibiotics had been prescribed within the previous 6 months for 10 of the 12, but clinical specimens had only been sent for three. In August

2010, 2 months before the study commenced, one of these residents had asymptomatic bacteriuria with an ESBL-producing *E. coli* (with identical antibiotic resistance profile). Thus, the clinical rate of infection with an ESBL-producing strain was 7% (1/14).

Antibiotic surveillance showed that during the 15 months before the study commenced, residents in the facilities studied received antibiotics for 445 episodes, 44% of which did not fulfil the criteria for bacterial infection.

Thirteen of the 14 residents colonised with ESBL-producing *E. coli* had repeat faecal specimens tested at least 3 months later. Of these, eight remained positive, including the resident with the positive urine specimen in August 2010.

Discussion

We found that rates of VRE and *C. difficile* colonisation in RACF residents were low, but that 12% overall, and up to 27% of residents in one RACF, were colonised with ESBL-producing *E. coli*.

The incidence of VRE has been increasing exponentially within our health service and others in eastern Australia.²⁵ Many factors contribute to this, including increases in antibiotic consumption, numbers of patients at risk of VRE acquisition, and patient transfers between hospitals and RACFs. There is also likely to be a new VRE strain that is spreading rapidly across Melbourne hospitals.²⁵ A Melbourne study performed in 1999 showed that 3% of 290 RACF residents were colonised with VRE.²⁶ Given its increased incidence in acute care hospitals, it is surprising that our findings remain similar to this. However, VRE does appear to be an uncommon pathogen in RACF residents.²⁷ It would have been of interest to assess the environment of the facilities for VRE, as environmental burden is a known risk factor for VRE acquisition.²⁸

Similarly, we found a low rate of *C. difficile* colonisation. Although this low rate is comforting, only 2% of residents had diarrhoea, and there were no residents with clinical evidence of *C. difficile* infection at the time of our study.

RACF residents may be an important reservoir of ESBL-containing

antibiotic-resistant *E. coli*. There is growing international literature on the problem of multiresistant gram-negative bacteria in RACFs, but information from within Australia is scant. A US study found that 15% of 117 residents in one facility in Illinois were colonised with ESBL-producing *E. coli*,²⁹ while a study in Boston found that 51% of 84 residents were colonised with multiresistant gram-negative bacteria.⁷ Rates of up to 75% have been found among nursing home residents in Northern Ireland.³⁰

Our study showed a clonal relatedness of ESBL-producing isolates, a finding seen previously in RACFs.^{9,31,32} Poor infection control practices may facilitate spread of this plasmid-mediated resistance. In the acute care setting, patients with multiresistant gram-negative bacteria are placed in contact isolation to limit spread, but this is difficult to implement in RACFs. As is common in many RACFs, residents in the facilities we studied share common dining rooms and recreational areas, enabling direct resident-to-resident spread. Environmental contamination and poor hand hygiene are also likely contributors to spread of multiresistant gram-negative bacteria. Although residents in each of the Facility A wings do not interact, nursing staff and cleaners work in both wings, which may explain the presence of the strain in both wings. Residents in Wing X are also highly mobile, making infection control interventions such as hand hygiene and environmental cleaning difficult. CTX-M enzymes have been detected in *E. coli* throughout Australia and are well established throughout the community.³³

The use of broad-spectrum oral antibiotics is associated with development of resistance, with fluoroquinolone use being strongly associated.³⁴ In addition to β -lactams, the predominant ESBL-producing strain in this study was resistant to norfloxacin, ciprofloxacin and trimethoprim, antibiotics used commonly in older people, supporting a role for antibiotic selective pressure. Although there was no association between ESBL carriage and antibiotic consumption in the previous month, 10 of 12 residents colonised with ESBL-producing organisms had

received antibiotics within the previous 6 months.

Also evident in our study was the prescription of antibiotics without clinical samples being collected to direct the treatment course. Having monitored antibiotic use in the RACFs over the previous 15 months, we found that, on average, 44% of prescribed antibiotics did not fulfil published criteria for clinical infection.¹⁷ Antibiotic stewardship is of paramount importance in RACFs, but it must also take into account the complexities of prescribing to frail older people who may present with atypical symptoms of infection and in whom early treatment may prevent significant deterioration.

The rate of clinical infection with an ESBL-producing strain that we found (7%) is likely to be an underestimate, given the lack of clinical specimens in the group. However, others have documented the association between colonisation and subsequent infection.³⁵ An Israeli study showed that 15% of hospitalised patients colonised with multiresistant gram-negative bacteria subsequently developed bacteraemia with the same strain, while a US study showed that 25% developed a urinary tract infection.^{15,36}

The duration of colonisation with multiresistant gram-negative bacteria is not well known but is vital to understanding the need for ongoing infection control interventions in the health care setting. We found that eight of 13 residents remained colonised with ESBL-producing *E. coli* for at least 3 months, with one resident having persistent carriage for more than 7 months. A French study has previously found one patient to remain colonised for at least 5 years.³⁷

A limitation of our study is the small number of facilities and patients included, meaning our data may not be generalisable to other RACFs. Similarly, our finding that the majority of ESBL-producing isolates were clonal in nature may signify a localised outbreak rather than a broader issue facing other RACFs. More studies in this setting are required.

In conclusion, we identified a high prevalence of ESBL-producing *E. coli* colonisation in RACFs. It is likely that the development of a resistant strain, under selective pressure from antibi-

otic use, has spread rapidly in an environment that is conducive to rapid dissemination. Antimicrobial resistance in RACFs is of growing concern, and regular surveillance for antibiotic resistance patterns is needed. RACFs should have programs emphasising processes that will limit spread of these organisms, namely good hand hygiene compliance, enhanced environmental cleaning and dedicated antimicrobial stewardship programs.

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