


Concise Communication

Association between level of care and colonization with resistant gram-negative bacteria among nursing-home residents

Timileyin Y Adediran MPH, CIC¹ , Kinjal N Sethuraman MD, MPH², Surbhi Leekha MBBS, MPH¹ and Mary-Claire Roghmann MD, MS¹

¹Department of Epidemiology and Public Health, University of Maryland School of Medicine, Baltimore, Maryland and ²Department of Emergency Medicine, University of Maryland School of Medicine, Baltimore, Maryland

Abstract

In this cross-sectional study, we examined the relationship between resident level of care in the nursing home and colonization with resistant gram-negative bacteria. Residential-care residents were more likely to be colonized with resistant gram-negative bacteria than were postacute care residents (odds ratio, 2.3; 95% confidence interval, 1.40–3.80; $P < .001$).

Keywords: Post-acute care; Resistant gram-negative bacteria; colonization; transmission; Nursing home residents

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Colonization with resistant gram-negative bacteria (R-GNB) can increase the morbidity and mortality among nursing home residents. Previous studies have conducted point prevalence studies among several nursing homes in California and found the prevalence of ESBL were about 34% and 16%, respectively.^{1,2}

In 2014, there were ~15,600 nursing facilities with 1.7 million beds in the United States.³ Of each 5 hospital stays covered by Medicare, 1 resulted in a discharge to a nursing home.³ Most of these facilities provide 2 levels of care: postacute care (after hospital discharge for acute illness and expected to be discharged) and residential care (for chronic medical conditions that limit independent living).

A recent study found a high prevalence of R-GNB colonization among newly admitted, postacute care residents at nursing facilities.³ However, no studies have compared postacute care to residential care with respect to R-GNB colonization. In this study, we examined the relationship between resident level of care and R-GNB colonization.

Methods

We conducted a secondary analysis of cross-sectional data gathered during a multicenter prospective cohort study of residents in 13 community-based nursing homes in Maryland and Michigan from 2012 to 2014.⁴ Overall, 403 residents were enrolled in the original study. Data forms with demographic and clinical information were completed by interviewing nursing staff and review of medical and administrative records.⁵ Microbiology methods were reported in a previous study.⁴ Research coordinators

collected cultures of anterior nares and perianal skin of study residents. Ultimately, 396 patients had complete information and were analyzed for this study. The primary outcome for our analysis was colonization with R-GNB defined as at least 1 swab from any site with growth of any GNB nonsusceptible (ie, intermediate or resistant) to at least 1 of the following antibiotic classes: fluoroquinolones, third-generation cephalosporins, or carbapenems. The exposure of interest was the resident's level of care (residential vs postacute care status) defined using the resource utilization group (RUG) score, which is used to determine the long-term needs of patients in nursing-home settings.⁶ Residents with a RUG score beginning with R, which means they are in the rehabilitation plus extensive care category or rehabilitation category, were determined to be post-acute residents.⁷

We analyzed the distribution of study population characteristics using the χ^2 test or the Student t test. Variables associated with exposure and outcome at $P \leq .10$ were considered for inclusion in a multivariable logistic regression model for the association between level of care (residential care vs postacute care) and R-GNB colonization. Data analysis was conducted in SAS version 9.4 software (SAS Institute, Cary, NC). This study was approved by the institutional review boards of the University of Maryland Baltimore and the University of Michigan.

Results

Of 396 residents, 235 (59%) received postacute care and 161 (41%) received residential care. Compared to postacute care residents, residential care residents were less likely to have a surgical wound (5% vs 28%; $P < .001$), antibiotic use within 7 days prior to enrollment in the study (14% vs 30%; $P < .001$), and hospitalization within the previous 3 months (28% vs 86%; $P < .001$). However, residential-care residents were more likely to be totally dependent on healthcare personnel (33% vs 4%; $P < .001$) and to have dementia (35% vs 9%; $P < .001$).

Author for correspondence: Mary-Claire Roghmann, E-mail: mroghmann@som.umaryland.edu. Or Timileyin Adediran, E-mail: tadediran@som.umaryland.edu

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Table 1. Demographic and Clinical Characteristics of Nursing Home Residents Stratified by Colonization Status (N = 396)

Patient Characteristics	Colonization (n = 106)	No Colonization (n = 290)	P Value
Age, median y (IQR)	80.0 (70.0–87.0)	80.0 (70.0–87.0)	.96
Sex, male	31 (29.3)	90 (31.3)	.73
Race, no. (%)			.25
White	86 (81.1)	219 (75.5)	
Other	20 (18.9)	70 (24.3)	
Hispanic or Latino	1 (1.0)	2 (0.7)	1.0
Total dependence on healthcare personnel	27 (25.5)	36 (12.4)	<.001
Indwelling catheter	8 (7.6)	27 (9.3)	.58
Medical device(s)	13 (12.3)	34 (11.8)	.90
Chronic wound	27 (25.5)	39 (13.5)	.01
Surgical wound(s)	12 (11.3)	62 (21.5)	.02
Hospitalization within 3 months prior to enrollment	51 (48.1)	196 (67.8)	<.001
Antibiotic use in previous 7 days prior to enrollment	25 (24.8)	66 (23.0)	.72
Comorbidities, no. (%)			
Peripheral vascular disease	15 (14.4)	32 (11.1)	.36
Renal failure	10 (11.3)	42 (16.3)	.26
Diabetes mellitus	45 (42.5)	103 (35.6)	.22
Arthritis	27 (30.3)	83 (32.2)	.75
Stroke	21 (19.8)	46 (16.1)	.39
Dementia	23 (21.9)	52 (18.6)	.46
Hemiplegia	6 (5.7)	12 (4.2)	.59
Level of care, no. (%)			<.001
Residential care	61 (57.5)	100 (34.5)	
Postacute care	45 (42.5)	190 (65.5)	

Note. IQR, interquartile range.

Of 396 residents, 106 (27%) were colonized with 154 R-GNB. The most common types of R-GNB among colonized residents were *Proteus mirabilis* (29%), *Escherichia coli* (25%), *Morganella morganii* (12%), *Pseudomonas aeruginosa* (10%), and all others (24%). Most isolates were from the Enterobacteriaceae family (n = 132, 86%). Among these 132 isolates from the Enterobacteriaceae family, 108 (82%) were resistant to ciprofloxacin, 45 (34%) were resistant to imipenem, and 27 (20%) were resistant to ceftazidime. Among the *Acinetobacter* spp, 5 (83.3%) were resistant to ciprofloxacin, 3 (50.0%) were resistant to imipenem, and 5 (83.3%) were resistant to ceftazidime. Most *Pseudomonas* spp were resistant to ciprofloxacin (n = 14, 88%); and 6 were resistant to ceftazidime (38%), and 7 were resistant to imipenem (40%). Of 154 isolates, 55 (36%) were resistant to >1 of the tested antibiotics: 41 (76%) Enterobacteriaceae isolates, 4 (7%) *Acinetobacter* spp isolates, and 10 (18%) *Pseudomonas aeruginosa*.

Compared to residents who were not colonized with R-GNB, colonized residents were more likely to be totally dependent on healthcare personnel (25% vs 13%; $P < 0.001$) and to have a chronic wound (25% vs 13%; $P = 0.01$). In contrast, colonized residents were less likely to have surgical wounds (11% vs 22%; $P = .02$) and to have been hospitalized within the previous 3 months (48% vs 68%; $P < .001$) (Table 1).

Indeed, while the prevalence of R-GNB among post-acute care residents in our study was high (19%), it was even higher among

Table 2. Association Between Level of Care and R-GNB Colonization in 396 Residents From 13 Nursing Homes in Maryland and Michigan, 2012–2014

Variables	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Residential care (vs post-acute care)	2.58 (1.63–4.06)	2.31 (1.40–3.80)
Surgical wound	0.47 (0.24–0.90)	
Chronic wound	2.20 (1.27–3.82)	2.23 (1.26–3.94)
Total dependence on healthcare personnel	2.41 (1.38–4.22)	1.55 (0.84–2.87)
Hospitalization within 3 months prior to enrollment	0.44 (0.28–0.69)	
Antibiotic use in previous 7 days prior to enrollment	1.10 (0.65–1.87)	

Note. OR, odds ratio; CI, confidence interval.

residential care participants (38%). Residential care was associated with higher odds of R-GNB colonization compared to postacute care (odds ratio [OR], 2.60; 95% confidence interval [CI], 1.60–4.0; $P < .001$). After adjusting for total dependence on healthcare personnel and presence of a chronic wound, residential care residents remained with a higher odds of R-GNB colonization (OR, 2.30; 95% CI, 1.40–3.80; $P < .001$) (Table 2).

Discussion

In this study, residents in residential care had a higher odds of R-GNB colonization compared to residents in postacute care. We hypothesize that the difference in R-GNB colonization prevalence between the two groups of residents are due to greater exposure to the healthcare environment and antibiotics in the residential care residents. Unfortunately, we cannot test these explanations because we only measured antibiotic use within seven days of enrollment and did not measure cumulative healthcare exposure. In a recent study examining R-GNB prevalence, Mody *et al*³ found that 32% of newly admitted postacute-care residents were colonized with R-GNB³. In contrast the prevalence of R-GNB among post-acute care residents in our study was 19% with a higher prevalence (38%) among residential care residents. Our study results are similar to previous studies assessing risk factors for resistant bacteria in nursing-home residents that found that length of stay was a risk factor for multidrug-R-GNB colonization.^{8,9} The higher risk likely reflects the risk of acquisition accumulated through prolonged exposure to other colonized residents. A longitudinal study found that among residents who acquired an MDRO during a 14-month period, 57% became positive in long-term care facilities, compared to 41% who became positive in the acute-care hospital and 2% who became positive from other settings such as private apartment or home. These findings support the spread of R-GNB during long-term residence in nursing homes.¹⁰

In our study, residential-care participants were more likely to be colonized even after adjusting for the presence of a chronic wound. Chronic wound was found to be an independent factor in our study. Similar to our study, a study of 29 Belgian nursing homes found that pressure sores or skin ulcers were a risk factor for extended-spectrum β -lactamase Enterobacteriaceae carriage ($P < .001$).¹¹ Similarly, O'Fallon *et al*⁸ found a pressure injury to be associated with R-GNB colonization.⁸ The higher risk related to chronic wounds may have been due to past courses of antibiotics to treat suspected wound infections.

Because of the cross-sectional study design of this study, we were unable to assess where transmission occurred. This study may also be limited by selection bias because we asked for informed consent from the resident or their legally authorized representation. Residents who were enrolled in the study may have differed from those who did not enroll in the study.

In conclusion, residential-care residents are more likely to be colonized with R-GNB potentially through transmission from other colonized residents or under antibiotic selection pressure. Residential-care residents may represent a reservoir for transmission of resistant bacteria in nursing facilities and suggests that postacute-care residents should be isolated in cohorts separate from residential-care residents. Our findings underscore the importance of infection control precautions to limit transmission

through a greater focus on infection prevention and antibiotic stewardship in nursing homes.

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Conflicts of interest. All authors report no conflicts of interest relevant to this article.

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