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Indwelling Device Use and Antibiotic Resistance in Nursing Homes: Identifying a High-Risk Group

Lona Mody[*,‡], **Shweta Maheshwari**[*], **Andrzej Galecki**[*], **Carol A. Kauffman**[†,§], and **Suzanne F. Bradley**[*,†,‡,§]

[*]Division of Geriatric Medicine, University of Michigan Medical School, Ann Arbor, Michigan

[†]Division of Infectious Diseases, University of Michigan Medical School, Ann Arbor, Michigan

[‡]Geriatric Research, Education and Clinical Center, Veteran Affairs Ann Arbor Healthcare System, Ann Arbor, Michigan

[§]Infectious Diseases Section, Veteran Affairs Ann Arbor Healthcare System, Ann Arbor, Michigan

Abstract

Objectives—To quantify the relationship between indwelling devices (urinary catheters, feeding tubes, and peripherally inserted central catheters) and carriage of antimicrobial-resistant pathogens in nursing home residents.

Design—Cross-sectional.

Setting—Community nursing home in Southeast Michigan.

Participants—Residents with indwelling devices (n = 100) and randomly selected control residents (n = 100) in 14 nursing homes.

Measurements—Data on age, functional status, and Charlson comorbidity score were collected. Samples were obtained from nares, oropharynx, groin, wounds, perianal area, and enteral feeding tube site. Standard microbiological methods were used to identify methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), and ceftazidime-resistant (CTZ-R) gram-negative bacteria (GNB).

Results—Use of indwelling devices was associated with colonization with MRSA at any site (odds ratio (OR) = 2.0, $P = .04$), groin (OR = 4.8, $P = .006$), and perianal area (OR = 3.6, $P = .01$) and CTZ-R GNB at any site (OR = 5.6, $P = .003$). Use of enteral feeding tubes was associated with MRSA colonization in the oropharynx (OR = 3.3, $P = .02$).

Address correspondence to Lona Mody, MD, 11-G GRECC, VA Ann Arbor Healthcare System, 2215 Fuller Rd, Ann Arbor, MI 48105. lonamody@umich.edu.

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Conclusion—Use of indwelling devices is associated with greater colonization with antimicrobial-resistant pathogens. This study serves as an initial step in defining a high-risk group that merits intensive infection control efforts.

Keywords

antibiotic resistance; nursing homes; indwelling device use; MRSA

Infections in nursing home residents are a major cause of morbidity and mortality. Rates of infection in nursing homes approach those in hospitals, making infection control an important patient-safety and quality improvement concern.[1] Most data on interventions and outcomes of infection control measures have come from acute care settings.[2] Few studies have evaluated the efficacy of and adherence to these programs in nursing homes.[3,4] Nursing homes face unique challenges. One challenge is that turnover rates are high among healthcare workers in nursing homes. Lacking appropriate staff and with limited budgets, infection control practitioners are often employed on only a part-time basis.[5–7] Another challenge is that nursing home residents cannot easily be placed in isolation precautions and still participate in appropriate rehabilitation and social programs. Thus, infection control and surveillance in nursing homes must be simple, focused, practical, and efficient and accommodate their staffing, budget, and care needs.

Surveillance strategies that could lead to more efficiency include targeting efforts at certain areas of the facility, patient groups, or infection sites.[8] Such targeted efforts are increasingly common because of their potential to yield meaningful information that can lead to changes in practice.[9] One such high-risk group in nursing homes includes residents with indwelling devices. These devices can compromise host defenses by providing a route for colonization by antibiotic-resistant microorganisms, thereby increasing the risk of infection.[10–13]

The objectives of this study were to quantify the relationship between use of indwelling devices and colonization with antimicrobial-resistant organisms in residents of 14 community nursing homes and to understand the effect of functional status and comorbidity on this relationship. Prior research has not determined the confounding effect of functional status on the association between use of indwelling devices and resistant microorganisms. It was hypothesized that residents with indwelling devices would have a higher rate of colonization with antimicrobial resistant pathogens than residents without such devices.

Methods

Study Design and Participants

An analytical, cross-sectional, epidemiological study was conducted in 14 community nursing homes in southeast Michigan from March 2003 to November 2004. In each nursing home, all cultures were obtained within a 2-week period. The University of Michigan institutional review board and the Veterans Affairs Ann Arbor Healthcare System human studies committee approved this study. After obtaining written informed consent, residents with an indwelling urinary catheter, percutaneous feeding-tube, or peripherally inserted central catheter (PICC line) or randomly selected nursing home residents without indwelling devices (control group) were enrolled. All residents with an enteral feeding tube, a urinary catheter, or a PICC line (device group) were eligible for the study. Refusal of informed consent was the only exclusion criterion. There were no specific ongoing or new infection-control initiatives during the study period.

Clinical and Demographic Data

Demographic data on age, sex, and indication for insertion of the device were obtained using patient chart review. The Lawton and Brody physical self-maintenance scale was used to assess functional status;[14,15] scores range from 6 to 30, with 6 being independent in all activities of daily living and 30 being dependent in all activities of daily living. The Charlson Comorbidity Index was used to assess comorbidity.[16] Antibiotic use within 30 days before culture was recorded in all residents with indwelling devices and 63 residents in the control group; these data were unavailable in 37 residents in the control group.

Microbiological Methods

Samples to assess colonization with antimicrobial-resistant organisms were obtained from anterior nares, oropharynx, skin around the enteral feeding tube, groin, perianal area, and wounds for the device and control groups using Culturette rayon-tipped swabs (Becton Dickenson, Inc., Cockeysville, MD) that were transported in transport medium and streaked onto agar plates within 2 hours.

To identify *Staphylococcus aureus*, samples were streaked onto mannitol salt agar plates and incubated at 35°C for 48 hours. All bright yellow colonies suggestive of *S. aureus* were picked, streaked onto trypticase soy agar plates containing 5% sheep's blood (Becton-Dickinson), and incubated at 35°C for 24 hours. Colonies of *S. aureus* were identified using a rapid test for staphylococcal protein A, with verification using tube coagulase assay if needed. Methicillin-resistant *S. aureus* (MRSA) colonies were identified according to growth on Mueller-Hinton agar containing 6 μg/mL of oxacillin and 4% sodium chloride.[17]

Vancomycin-resistant enterococci (VRE) were identified by streaking samples onto bile esculin azide agar containing 6 μg/mL of vancomycin and 5 μg/mL of gentamicin. Black colonies were streaked onto trypticase soy agar plates containing 5% sheep's blood for 24 hours and then Gram stain, catalase test, and the pyroglutamate aminopeptidase test (Hardy Diagnostics, Santa Maria, CA) were used to identify enterococci.[3]

To identify gram-negative bacilli (GNB), samples were streaked onto MacConkey agar (Difco Inc., Livonia, MI), and the plates were incubated at 35°C for 24 hours. All phenotypically different colonies were identified to the species level using API-20E test strips (Analytab Products, Plainview, NY). Screening for ceftazidime resistance (CTZ-R) was determined by inoculating organisms onto MacConkey agar containing 10 μg/mL of ceftazidime.[18]

Statistical Methods

Data were entered into a Microsoft Excel (Microsoft Corp., Redmond, WA) spreadsheet and analyzed using Stata 8.2 (College Station, TX). Univariate analysis was performed to examine the spread of data. An analysis was conducted to compare the odds of colonization with antibiotic-resistant organisms—MRSA, VRE, and CTZ-R GNB—in residents with indwelling devices with those of controls while controlling for confounding variables. Logistic regression models were used to assess the effect of device use on antibiotic-resistant organisms while controlling for age, functional status, nursing home site, and Charlson score. Functional status and Charlson score were measured on a continuous scale. Contribution of a variable to a model was assessed using the likelihood ratio test). Crude and adjusted odds ratios (ORs) and 95% confidence intervals were produced for each outcome.

Results

Demographic Characteristics

A total of 125 residents from 14 nursing home facilities that contained a total of 1,669 beds and who had an indwelling urinary catheter, an enteral feeding tube, or a PICC line were eligible for the study. An equal number of controls were randomly selected from the same nursing home using a random numbers table. Of these 250 residents, 37 refused consent (Table 1). Therefore, 213 residents (105 residents with one or more indwelling devices and 108 residents without an indwelling device) were enrolled in this cross-sectional study. Functional status score was missing for 13 residents: five with devices and eight without. Thus, for the final analysis, there were 100 residents in the indwelling device group and 100 in the control group. Forty-five residents had an indwelling urinary catheter only, 45 residents had an enteral feeding tube only, six residents had both a urinary catheter and an enteral feeding tube, and four residents had a PICC line only. Of the enteral feeding tubes, 47 were gastrostomy tubes, and four were gastrojejunal tubes; no resident had a nasogastric tube. There were 20 residents who had wounds, 16 in the device group and four in the control group.

Table 2 presents the age, functional status, and comorbidity demographics of the two groups. The device group was slightly younger and had poorer functional status and more comorbid illnesses than the control group. Indications for urinary catheter use included bladder retention (42%), unspecified (34%), incontinence (16%), and comfort care (6%). Indications for feeding tube use included dysphagia (64%), unspecified (14%), weight loss (12%), and advanced dementia (4%).

Use of Any Indwelling Device and Colonization with Antibiotic-Resistant Organisms

Of 100 residents in the device group, 55 were colonized with MRSA at any site, compared with 23 in the control group (adjusted OR = 1.97, $P = .04$) (Table 3). Residents in the device group were more likely than those in the control group to be colonized with MRSA in the groin (26% vs 5%, adjusted OR = 4.8, $P = .006$) or perianal area (28% vs 7%, adjusted OR = 3.6, $P = .01$) after adjusting for functional status, comorbidity, and age. Three residents in the device group and one resident in the control group were colonized with MRSA in their wounds. Colonization with VRE did not differ between the two groups.

Residents in the device group were more likely than those in the control group to be colonized with GNB in their oropharynx (32% vs 14%, adjusted OR = 3.9, $P = .002$) and perianal area (28% vs 7%, adjusted OR = 3.6, $P = .011$). Twenty-four (24%) residents in the device group were colonized with CTZ-R GNB, compared with five (5%) in the control group (adjusted OR = 5.6, $P = .003$) (Table 3).

There were no significant differences in antimicrobial usage in the device group colonized with CTZ-R GNB (14/24, 58%) and those not colonized with CTZ-R GNB (51/76, 67%). Similarly, antimicrobial use in the device group did not differ between those colonized with MRSA (36/55, 66%) and those not colonized with MRSA (29/45, 64%). The numbers of resistant pathogens were small in the control group, and hence the effect of antibiotic use could not be assessed.

Use of Urinary Catheters and Colonization with Antibiotic-Resistant Organisms

Of the 51 residents who had an indwelling urinary catheter, 28 (55%) were colonized with MRSA at any site. Residents who had urinary catheters were 2.8 times ($P = .01$) as likely to be colonized with MRSA as those in the control group, although the relationship between urinary catheter use and MRSA colonization at any site did not remain significant after

adjusting for functional status, comorbidity, and age (adjusted OR = 1.4, $P = .4$). Examining specific body sites, residents who had urinary catheters were more likely to be colonized with MRSA in the groin (34% vs 5%, adjusted OR = 4.5, $P < .001$) and perianal area (38% vs 7%, adjusted OR = 4.3, $P = .006$) than those the control group. Nasal colonization with MRSA did not differ significantly between the two groups (42% in residents with urinary catheters, 23% in control group, adjusted OR = 1.3, $P = .5$). Colonization with VRE did not differ between the two groups (Table 4). Fourteen (28%) residents who had urinary catheters were colonized with CTZ-R GNB, compared with five (5%) of controls at any site (adjusted OR = 7.8, $P = .002$) (Table 4).

Use of Enteral Feeding Tubes and Colonization with Antibiotic-Resistant Organisms

Of the 51 residents who had an enteral feeding tube, 31 (61%) were colonized with MRSA at any site (Table 5). Residents who had a feeding tube were 3.4 times as likely to be colonized with MRSA as those in the control group ($P = .001$). This relationship remained significant after adjusting for functional status, comorbidity, and age (adjusted OR = 2.6, $P = .047$). Examining specific body sites, residents with feeding tubes were more likely to be colonized with MRSA in the oropharynx (36% vs 11%, adjusted OR = 3.27, $P = .02$), groin (22% vs 5%, adjusted OR = 5.8, $P = .02$), and perianal area (24% vs 7%, adjusted OR = 3.4, $P = .05$) than those in the control group. Nasal colonization did not differ significantly between the two groups (30% in residents with urinary catheters, 23% in control group, adjusted OR = 1.0, $P = .9$). Colonization with VRE did not differ between the two groups (Table 5).

Residents who had enteral feeding tubes were more likely to be colonized with GNB in their oropharynx (50% vs 14%, adjusted OR = 7.3, $P < .001$) than those in the control group. Thirteen residents (26%) with enteral feeding tubes were colonized with CTZ-R GNB, compared with five (5%) controls (adjusted OR = 7.1, $P = .006$).

Discussion

This cross-sectional study showed that use of indwelling devices to provide care to nursing home residents was associated with a higher colonization rate with MRSA and CTZ-R GNB but not VRE. Prior studies have shown indwelling devices to be a risk factor for colonization and infection with MRSA and resistant GNB in a nursing home population; this study quantifies this risk and establishes that the risk persists after adjusting for functional status, age, and comorbidity.[18–20] Multivariate analysis showed that residents with indwelling devices were four to five times as likely to be colonized with MRSA in the perianal area and groin as were controls.

For individual devices, presence of a urinary catheter was independently associated with localized MRSA colonization in the groin and perianal area and CTZ-R GNB colonization at any site. For enteral feeding tubes, an independent association with MRSA colonization in the oropharynx, groin, and perianal area was seen. One interpretation could be that the type of device may influence the site of colonization. The fact that MRSA colonization in the nares was not different between residents who did and did not have indwelling devices exemplified this. Residents with indwelling urinary catheters were more likely than those in the control group to be colonized with MRSA in the groin and the perianal area, sites that are often not studied when performing surveillance cultures. More studies are required to confirm these findings.

Prior research has not determined the confounding effect of functional status on the association between indwelling device use and resistant organisms. Although the mechanism is unknown, functional status is felt to increase the risk of colonization with antibiotic-

resistant organisms.[12,21,22] In the current study, residents with indwelling devices were more functionally impaired than those without. The OR for MRSA colonizing any site was diminished but still significant after adjusting for functional status, suggesting that functional status had some influence. Because this study focused only on feeding tubes and urinary catheters as the primary risk factors and quantified their effect on colonization by antibiotic-resistant organisms, residents were sampled based on their device status. Further research should be performed to evaluate a spectrum of residents with varying levels of function to explain further the association between functional impairment and colonization with antibiotic-resistant organisms.

This study has practical implications for infection control practices in nursing homes. Considering the magnitude of risk of colonization imposed by these devices, this group could be targeted for intensive surveillance and infection control practices. Significant debate exists on prospective culturing of patients admitted to acute care hospitals.[23,24] Despite a lack of data, some guidelines suggest that prospective culturing should also be part of a nursing homes' infection control agenda.[25] The feasibility of such an undertaking needs to be evaluated further, but it is conceivable that a nursing home could aggressively focus on its high-risk residents, such as those with devices, rather than performing cultures on all residents. Further research is required to demonstrate the effectiveness of this approach. Future studies should also focus on nursing home residents with indwelling devices admitted to acute care hospitals and their risk of acquiring or transmitting antibiotic-resistant organisms in this setting.

This study has several limitations. First, a cross-sectional design does not allow a temporal relationship between the presence of antibiotic-resistant organisms and indwelling devices or the effect of hospitalization and antibiotic use related to device use to be determined. Data were not collected on hospitalization or duration of nursing home stay; these are being addressed in a prospective cohort study. Second, few residents in the control group had resistant gram-negative organisms. Although the findings are interesting, a larger sample of control residents will be required to conduct complex regression analyses. Similarly, no difference was detected in VRE colonization between the device and the control group. This lack of difference could be because the presence of devices was not associated with VRE colonization or because of inadequate power to detect such a difference. Third, information bias may occur when an investigator is aware of the association under study. It was minimized by having a strict objective definition of the outcome of interest, using a standardized method of data collection, and ensuring that the microbiologist who assessed the presence of various microorganisms was not aware of exposure status. Fourth, the results cannot be extrapolated to surveillance procedures for antibiotic resistance in other settings, such as acute care hospitals, although the results suggest that cultures from multiple sites would be required to accurately identify all MRSA carriers among nursing home residents admitted to an acute care hospital.

Involving multiple freestanding nursing homes makes this study more generalizable, which is a major strength. It gives important information on the distribution and burden of indwelling devices (exposures) and antibiotic-resistant organisms (outcomes). This study is the first step in defining a high-risk group of nursing home residents that can serve as the focus of further intensive infection control efforts. Further research should focus on time to colonization, transmission patterns of these organisms in nursing homes, defining other high-risk groups (e.g., those with pressure ulcers or severe functional impairment), and assessing the effect of interventions focused on these high-risk groups.

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References

1. Strausbaugh LJ, Joseph CL. The burden of infection in long-term care. Infect Control Hosp Epidemiol. 2000; 21:674–679. [PubMed: 11083186]
2. Haley RW, Culver DH, White JW, et al. The efficacy of infection surveillance and infection control programs in preventing nosocomial infections in US hospitals. Am J Epidemiol. 1985; 121:182–205. [PubMed: 4014115]
3. Mody L, McNeil SA, Sun R, et al. Introduction of waterless alcohol based handrub in a long-term care facility. Infect Control Hosp Epidemiol. 2003; 24:165–171. [PubMed: 12683506]
4. Thompson BL, Dwyer DM, Ussery XT, et al. Handwashing and glove use in a long-term-care facility. Infect Control Hosp Epidemiol. 1997; 18:97–103. [PubMed: 9120250]
5. Smith PW. Nursing home infection control: A status report. Infect Control Hosp Epidemiol. 1998; 19:366–369. [PubMed: 9613700]
6. Goldrick BA. Infection control programs in skilled nursing long-term care facilities: An assessment. Am J Infect Control. 1999; 27:4–9. [PubMed: 9949372]
7. Leinbach RM, English AJ. Training needs of infection control professionals in long-term care facilities in Virginia. Am J Infect Control. 1995; 23:73–77. [PubMed: 7639406]
8. Horan, TC.; Gaynes, RP. Surveillance of nosocomial infections. In: Glen May-hall, C., editor. Hospital Epidemiology and Infection Control. 3rd. Philadelphia: Lippincott Williams & Wilkins; 2004. p. 1659-1703.
9. Singh N, Squier C, Wannstedt C, et al. Impact of an aggressive infection control strategy on endemic *Staphylococcus aureus* infection in liver transplant recipients. Infect Control Hosp Epidemiol. 2006; 27:122–126. [PubMed: 16465627]
10. Bradley SF. Issues in the management of resistant bacteria in long-term-care facilities. Infect Control Hosp Epidemiol. 1999; 20:362–366. [PubMed: 10349960]
11. Terpenning MS, Bradley SF, Wan JY, et al. Colonization and infection with antibiotic-resistant bacteria in a long-term care facility. J Am Geriatr Soc. 1994; 42:1062–1069. [PubMed: 7930330]
12. Trick WE, Weinstein RA, DeMarais PL, et al. Colonization of skilled-care facilities with antimicrobial-resistant pathogens. J Am Geriatr Soc. 2001; 49:270–276. [PubMed: 11300237]
13. Smith PW, Seip CW, Schaefer SC, et al. Microbiologic survey of long-term care facilities. Am J Infect Control. 2000; 28:8–13. [PubMed: 10679131]
14. Lawton MP, Brody EM. Assessment of older people: Self-maintaining and instrumental activities of daily living. Gerontologist. 1969; 9:179–186. [PubMed: 5349366]
15. Rockwood K, Howlett S, Stadnyk K, et al. Responsiveness of goal attainment scaling in a randomized controlled trial of comprehensive geriatric assessment. J Clin Epidemiol. 2003; 56:736–743. [PubMed: 12954465]
16. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. J Chronic Dis. 1987; 40:373–383. [PubMed: 3558716]
17. Mody L, McNeil SA, Kauffman CA, et al. Mupirocin prophylaxis for staphylococcal infection in nursing homes. CID. 2003; 37:1467–1474.
18. Weiner J, Quinn JP, Bradford PA, et al. Multiple antibiotic-resistant *Klebsiella* and *Escherchia coli* in nursing homes. JAMA. 1999; 281:517–523. [PubMed: 10022107]
19. Mendelson G, Hait V, Ben-Israel J, et al. Prevalence and risk factors of extended-spectrum beta-lactamase-producing Escherichia coli and Klebsiella pneumonia in an Israeli long-term care facility. Eur J Clin Microbiol Infect Dis. 2005; 24:17–22. [PubMed: 15660255]
20. Terpenning MS, Bradley SF, Wan JY, et al. Colonization and infection with antibiotic-resistant bacteria in a long-term care facility. J Am Geriatr Soc. 1994; 42:1062–1069. [PubMed: 7930330]

21. Bradley SF, Terpenning MS, Ramsey MA, et al. Methicillin-resistant Staphylococcus aureus: Colonization and infection in a long-term care facility. Ann Intern Med. 1991; 115:417–422. [PubMed: 1908198]

22. Tada A, Watanabe T, Yokoe H, et al. Oral bacteria influenced by the functional status of elderly people and the type and quality of facilities for the bedridden. J Appl Microbiol. 2002; 93:487–491. [PubMed: 12174048]

23. Jackson M, Jarvis WR, Scheckler WE. HICPAC/SHEA—conflicting guidelines: What is the standard of care? Am J Infect Control. 2004; 32:504–511. [PubMed: 15573060]

24. Strausbaugh LJ, Siegel JD, Weinstein RA. Preventing transmission of multidrug-resistant bacteria in health care settings: A tale of 2 guidelines. Clin Infect Dis. 2006; 42:828–835. [PubMed: 16477561]

25. Muto CA, Jernigian JA, Ostrowsky BE, et al. SHEA guideline for preventing nosocomial transmission of multidrug-resistant strains of Staphylococcus aureus and enterococci. Infect Control Hosp Epidemiol. 2003; 24:362–386. [PubMed: 12785411]

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Table 1

Number of Eligible and Enrolled Nursing Home Residents in Device and Control Groups

		Device Group		Control Group	
	Beds	**Eligible**	**Enrolled**	**Eligible**	**Enrolled**
Nursing Home			***n* (%)**		
1	94	6	4	6	4
2	204	8	5	8	8
3	102	4	3	4	3
4	153	6	5	6	5
5	82	5	4	5	4
6	92	14	11	14	13
7	180	13	12	13	12
8	74	6	5	6	5
9	71	7	6	7	7
10	230	11	7	11	11
11	102	10	9	10	9
12	103	10	9	10	9
13	144	20	20	20	16
14	38	5	5	5	2
Total	1,669	125	105 (84)	125	108 (86)

Table 2
Characteristics of Nursing Home Residents in Device and Control Groups

Characteristic	Device Group (*n* = 100)	Control Group (*n* = 100)	*P*-Value
Age, mean (95% CI)	77.5 (74.7–80.1)	81.09 (78.7–83.4)	.04
Male:female	40:60	33:67	.16
Physical Self-Maintenance score, mean (95% CI)	25.9 (24.9–26.8)	20.1 (18.8–21.4)	<.001
Charlson Comorbidity Index, mean (95% CI)	2.95 (2.5–3.3)	2.45 (2.1–2.7)	.04

CI = confidence interval.

Table 3

Colonization with Antibiotic-Resistant Organisms in Nursing Home Residents in Device and Control Groups

	Positive, %				
Outcome	**Device Group (*n* = 100)**	**Control Group (*n* = 100)**	**Crude OR**	**Adjusted OR (95% Confidence Interval)***	***P*-Value**
Methicillin-resistant *Staphylococcus aureus*	55	29	3.0	2.0 (1.01–3.8)	.04
Vancomycin-resistant enterococci	9	9	1.02	1.1 (0.4–3.4)	.88
Ceftazidime-resistant gram-negative bacteria	24	5	6.2	5.6 (1.8–17.8)	.003

* Adjusted for age, functional status, Charlson Comorbidity Index, and residence.

OR = odds ratio.

Table 4

Colonization with Antibiotic-Resistant Organisms in Nursing Home Residents with and without Urinary Catheters

	Urinary Catheters (*n* = 51)	Control Group (*n* = 100)			
Outcome	***n* (%)**		**Crude OR**	**Adjusted OR (95% Confidence Interval)***	***P*-Value**
Methicillin-resistant *Staphylococcus aureus*	28 (55)	29 (29)	2.8†	1.4 (0.6–3.2)	.4
Vancomycin-resistant enterococci	6 (12)	9 (9)	1.3	1.3 (0.4–4.2)	.8
Ceftazidime-resistant gram-negative bacteria	14 (28)	5 (5)	7.9†	7.8 (2.1–29.1)	.001†

*Adjusted for age, functional status, Charlson score, and residence.

†$P < .05$.

OR = odds ratio.

Table 5

Colonization with Antibiotic-Resistant Organisms in Nursing Home Residents with and without Enteral Feeding Tubes

	Enteral Tubes (*n* = 51)	Control Group (*n* = 100)			
Outcome	***n* (%)**		**Crude OR**	**Adjusted OR (95% Confidence Interval CI)***	***P*-Value**
Methicillin-resistant *Staphylococcus aureus*	31 (61)	29 (29)	3.4†	2.6 (1.2–5.5)†	.047†
Vancomycin-resistant enterococci	4 (8)	9 (9)	0.8	0.9 (0.2–3.8)	.9
Ceftazidime-resistant gram-negative bacteria	13 (26)	5 (5)	7.2†	7.1 (2.3–21.7)†	<.001†

*Adjusted for age, functional status, Charlson score, and residence.

†$P < .05$.

OR = odds ratio