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Incidence of Antibiotic-Resistant Infection in Long-Term Residents of Skilled Nursing Facilities

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Abstract

Background—Information regarding the incidence of antibiotic-resistant infection in residents of skilled nursing facilities is lacking.

Methods—Incidence and predictors of antibiotic-resistant infection were determined in 56,182 long-term residents of 3,314 skilled nursing facilities in California, Florida, Michigan, New York, and Texas.

Results—The annual incidence was 12.7 cases per 1000 long-term residents overall, which varied by state (highest incidence, New York) and type of admitting facility (highest incidence, rehabilitation hospital). The incidence was greater in younger residents, males, and in those with paraplegia, quadriplegia, peripheral vascular disease, or diabetes mellitus. Dialysis, urinary catheterization, feeding tubes, tracheostomy, and use of intravenous medications were associated with elevated risk. Adjusted odds ratios were greatest for residents with paraplegia (OR=2.86, 95% CI: 1.67, 4.89) and for individuals receiving dialysis (OR=2.84, 95% CI: 1.84, 4.37).

Conclusions—There is significant variation in the risk of antibiotic-resistant infection by admitting diagnoses, device use, and facility characteristics.

Keywords

antibiotic-resistant infection; sepsis; nursing homes

Long-term residents of skilled nursing facilities are a distinctive population, often living with considerable co-morbidities and functional ailments that require close oversight and management. Infection is not uncommon in this setting; approximately one to seven million infections occur in long-term care facilities every year (1). Antibiotic-resistant microorganisms are a rising concern due to the widespread use of empiric antibiotics and indwelling devices (2-5).

While important strides have been made in infection control and antimicrobial research in the past decade, population-based incidence rates of drug-resistant infections are lacking. We report here incidence rates of antibiotic-resistant infection in long-term residents of skilled nursing homes in five states.

Methods

All residents who were newly admitted in year 2003 to skilled nursing facilities in California, Florida, Michigan, New York, and Texas were followed for one year. Only long-term residents (i.e., those who remained within the facility for an entire year) were included. Data were obtained from the Long Term Care Minimum Data Set (MDS) from the Centers for Medicare and Medicaid Services (CMS).

At the time of admission and every 3 months thereafter, the presence of physician-documented antibiotic-resistant infection was recorded within the MDS. Instructions for coding stipulated any antibiotic-resistant infection, including (but not limited to) methicillin-resistant *Staphylococcus aureus* (MRSA), aminoglycoside-resistant *Staphylococcus aureus*, vancomycin-resistant enterococci, and extended-spectrum beta-lactamase organisms, in which there was supporting documentation from a physician in the clinical record (6). For purposes of this study, only incident (newly occurring) antibiotic-resistant infections were included; those residents with such infections at the time of admission were excluded (n=1120).

Annual cumulative incidence rates per 1000 residents were calculated by patient and facility characteristics, as recorded in the MDS at the time of admission. Unadjusted rate ratios were calculated with 95% test-based confidence intervals (CI). To adjust for all factors simultaneously, a generalized linear model was used with a logit link function, binomial distribution, and clustering by facility. Standard errors were calculated with the robust White/Huber sandwich estimator of variance. Imputation by best-subset regression was utilized for missing data, which ranged from 0% to 5.5% in the study variables. Population attributable risk (PAR) – the proportion of disease in the study population attributable to a specific factor – was calculated for device-related infection, using the adjusted coefficients from the final regression model. Alpha was set at 0.05, two-tailed. Analyses were conducted in Stata/SE 9.2.

This study received approval by CMS and the human subjects review board at the University of Michigan.

Results

There were 56,182 individuals admitted to 3,314 skilled nursing facilities in the five states who did not have an existing antibiotic-resistant infection at the time of admission and who remained within the facility for one year. Sixty-nine percent of the subjects were women, and 74.9% were non-Hispanic white. Over half (57.3%) were admitted from an acute-care hospital.

During the course of the year, 713 patients developed a new infection with an antibiotic-resistant pathogen while residing within the facility. The annual incidence of infection was 12.7 cases per 1000 residents. Of the 713 incident cases, 32.1% occurred during the first 3 months after admission; 19.5% occurred from 3-6 months after admission; 15.6% occurred from 6-9 months after admission; and 32.8% occurred from 9-12 months after admission. Sixteen percent of the 3,314 facilities reported incident cases, with 406 facilities having one incident case and 120 facilities having two or more incident cases within the one-year time period. New York exhibited the highest rate of infection (table 1) while California had the

lowest. There was an inverse association between age and rate of infection ($p<0.001$). Men had higher rates of infection than women. The incidence rate also varied across racial/ethnic categories, with Native Americans having the highest rate and Asians with the lowest. Patients who were admitted from a rehabilitation hospital or acute care hospital had higher rates than those admitted from other locations.

Incidence rates for patients presenting with specific diagnoses at the time of admission are listed in table 1. Residents with higher risk included those with neurological disease (comatose, quadriplegia, paraplegia, multiple sclerosis, brain injury), as well as those with missing limbs, peripheral vascular disease, or diabetes mellitus.

Devices associated with the highest incidence rates of antibiotic-resistant infection (table 1) were those related to respiratory care (tracheostomy care, suctioning, ventilator or respirator). Rates were also high for residents who used dialysis, nutritional therapies (feeding tube, parenteral or intravenous nutrition), an indwelling urinary catheter and intravenous medication.

When all the variables in table 1 were entered simultaneously into the generalized linear model, the following remained statistically significant: state where the skilled nursing facility was located, type of facility from which the patient was previously discharged, patient age, male sex, quadriplegia, paraplegia, peripheral vascular disease, diabetes mellitus, tracheostomy care, dialysis, indwelling urinary catheter, feeding tube, and intravenous medications. Residents in New York had three-fold the odds of antibiotic-resistant infection as residents in California. Residents in Texas and Florida also had a greater risk of infection compared to Californians. Paraplegia and use of dialysis were most strongly related to antibiotic-related infection, with adjusted odds ratios of 2.86 and 2.84 respectively.

The population attributable risk of antibiotic-resistant infection associated with device use was greatest for indwelling urinary catheters (PAR=14.2%) and lower for feeding tubes (PAR=8.5%), intravenous medications (PAR=6.3%), dialysis (PAR=2.0%), and tracheostomy care (PAR=1.8%).

Discussion

While the incidence of antibiotic-resistant infection in long-term residents of skilled nursing facilities was 12.7 per 1000 residents overall, there was considerable variability across states and for specific types of patients. New York, Florida, and Texas exhibited significantly higher rates than California. Younger residents were more likely to develop an antibiotic-resistant infection than older residents, regardless of the diagnoses present at the time of admission. Men were also at greater risk than women, when adjusted for other factors including indwelling catheter use. Incidence rates were considerably greater in patients with neurological conditions such as paraplegia, although there were relatively few of such patients within the facilities.

Risk was also elevated in patients with diabetes mellitus or peripheral vascular disease. These conditions were relatively common in residents; 25% had diabetes mellitus, and 8% had peripheral vascular disease. Similar to our findings, Terpenning and colleagues found that diabetes mellitus and peripheral vascular disease were risk factors for antibiotic-resistant infection, specifically methicillin-resistant *Staphylococcus aureus*, in a two-year prospective study of colonization and infection conducted within the Ann Arbor Veterans Administration Medical Center (3).

The incidence of invasive MRSA infection among patients receiving dialysis was reported as 45.2 cases per 1000 dialysis recipients in 2005, using information from the Active Bacterial Core surveillance system at the Centers for Disease Control and Prevention (7). This surveillance system encompasses a catchment area of Connecticut and 23 counties from eight other states, to yield population-based incidence rates. Their figure is comparable to our findings. We found an annual incidence rate of 42.3 antibiotic-resistant cases per 1000 dialysis patients in skilled nursing facilities. Muder and colleagues also found that dialysis was an independent predictor of antibiotic-resistant infection (8).

Invasive devices have been clearly identified as risk factors for the development of healthcare-associated infection (2). Terpenning and colleagues reported that urethral catheterization was a risk factor for infection with gentamicin-resistant enterococci (3). We also found urethral catheterization to be a predictor of antibiotic-resistant infection, with an odds ratio of over 2. In our study, indwelling urinary catheters accounted for the greatest proportion of device-related antibiotic-resistant infections in long-term residents. This was likely due to its common usage; in a review of 53 long-term care facilities in Maryland, 10% of women and 15% of men used a urine collection device of some kind (9).

The presence of a feeding tube or intravenous medication was also associated with a greater risk of antibiotic-resistant infection in our study. Similarly, Toubes and colleagues found that the presence of a feeding tube increased the odds of an antibiotic-resistant infection three-fold in hospitalized patients who had been transferred from long-term care facilities (10). Both the nutritional preparations and tube-rinsing solutions have been found to be sources of contamination (11). Loeb and colleagues reported that the use of intravenous therapy was strongly associated with MRSA, yielding a significant odds ratio of 8.55, in a prospective study of residents in 50 North American nursing homes (12).

Our findings should be interpreted in the context of the limitations inherent in relying upon a retrospective analysis of a clinical and administrative database. In particular, information was not available regarding the criteria used to determine the presence of antibiotic-resistant infection or the specific organisms involved. Certainly, clinically-evident infection has been shown to occur at a lower rate than the carriage of antibiotic-resistant bacteria (13). Bradley and colleagues found that 3% of patients in a long-term care facility developed MRSA infection over the course of one year while 10% were colonized (13).

Limitations notwithstanding, our study has several important findings. Using a very large database from five diverse states, we found considerable variability in the incidence rate of antibiotic-resistant infection by age, gender, and state. Residents with neurological illness, diabetes mellitus, and peripheral vascular disease were at elevated risk. Urinary catheterization, dialysis, tracheostomy, and the use of feeding tubes and intravenous medications were also associated with a greater incidence of antibiotic-resistant infection. Interventions in high-risk residents should be considered to prevent acquisition – and subsequent spread – of antibiotic resistance.

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Table 1
Annual incidence rates, unadjusted rate ratios, and adjusted odds ratios for antibiotic-resistant infection in long-term residents of skilled nursing facilities

Characteristics	Number	Incidence Rate ^a	Unadjusted Rate Ratio (95% CI)	Adjusted Odds Ratio (95% CI) ^b
All	56,182	12.7		
State:				
New York	16,585	19.8	2.70(2.15 - 3.39)	3.26 (2.53 - 4.20)
Florida	8,549	15.1	2.06(1.58 - 2.68)	2.24(1.68 - 2.98)
Texas	12,113	9.6	1.31 (1.00 - 1.71)	1.69(1.26 - 2.27)
Michigan	5,974	7.5	1.03(0.72 - 1.46)	1.15(0.78 - 1.70)
California	12,961	7.3	1.00, reference	1.00, reference
Age (years):				
&45	1,830	24.6	3.99 (2.26 - 7.03)	2.22(1.21 - 4.07)
45-54	2,382	20.6	3.33(1.90 - 5.85)	2.18(1.21 - 3.94)
55-64	4,021	17.2	2.78(1.62 - 4.78)	1.90(1.09 - 3.31)
65-74	7,548	14.6	2.36(1.40 - 3.98)	1.70(1.01 - 2.87)
75-84	19,367	13.8	2.24(1.36 - 3.71)	1.86(1.12 - 3.08)
85-94	18,441	8.5	1.37(0.82 - 2.29)	1.27(0.76 - 2.13)
≥95	2,593	6.2	1.00, reference	1.00, reference
Sex:				
Male	17,298	16.3	1.47(1.27 - 1.71)	1.21 (1.02 - 1.44)
Female	38,884	11.1	1.00, reference	1.00, reference
Race/ethnicity:				
Native American	196	25.5	2.75 (0.99 - 7.64)	2.79 (0.91 - 8.55)
Black, not Hispanic	7,259	13.4	1.44(0.81 - 2.57)	1.03(0.56 - 1.89)
White, not Hispanic	42,053	12.7	1.37(0.79 - 2.37)	1.59(0.90 - 2.81)
Hispanic	5,271	12.1	1.31 (0.72 - 2.37)	1.06(0.57 - 1.97)
Asian	1,403	9.3	1.00, reference	1.00, reference
Admitted from:				
Rehabilitation hospital	703	21.3	3.46 (2.02 - 5.92)	2.24(1.30 - 3.86)
Acute care hospital	32,173	16.9	2.74 (2.22 - 3.39)	1.60(1.27 - 2.03)
Nursing home	6,752	7.7	1.25(0.90 - 1.74)	1.00(0.71 - 1.42)
Other	16,554	6.2	1.00, reference	1.00, reference
Conditions at admission: ^c				
Comatose	266	101.5	8.27(5.74 - 11.92)	1.51 (0.87 - 2.64)
Quadriplegia	365	60.3	4.87 (3.23 - 7.35)	1.79(1.02 - 3.14)
Paraplegia	318	53.5	4.29 (2.69 - 6.85)	2.86(1.67 - 4.89)
Missing limb	962	31.2	2.52(1.76 - 3.61)	1.28(0.83 - 1.98)
Multiple sclerosis	609	29.6	2.36(1.49 - 3.75)	1.50(0.89 - 2.55)
Brain injury	380	28.9	2.30(1.28 - 4.14)	0.81 (0.41 - 1.62)
Peripheral vascular disease	4,294	23.3	1.97(1.60 - 2.43)	1.66(1.29 - 2.13)

Characteristics	Number	Incidence Rate ^a	Unadjusted Rate Ratio (95% CI)	Adjusted Odds Ratio (95% CI) ^b
Diabetes mellitus	13,931	19.0	1.79(1.54 - 2.09)	1.48(1.26 - 1.75)
Devices at admission: ^d				
Tracheostomy care	871	83.8	7.24(5.74 - 9.14)	1.96(1.01 - 3.81)
Suctioning	986	78.1	6.78(5.40 - 8.51)	1.30(0.68 - 2.47)
Ventilator or respirator	375	74.7	6.08 (4.23 - 8.75)	0.88(0.51 - 1.53)
Dialysis	614	42.3	3.43 (2.33 - 5.03)	2.84(1.84 - 4.37)
Feeding tube	4,180	40.7	3.89(3.29 - 4.61)	2.13(1.68 - 2.70)
Indwelling urinary catheter	6,794	34.4	3.55(3.04 - 4.14)	2.28(1.89 - 2.74)
Parenteral / IV nutrition	1,017	24.6	1.97(1.33 - 2.92)	1.16(0.73 - 1.83)
IV medication	8,046	23.9	2.20(1.87 - 2.60)	1.45(1.19 - 1.76)

^a Annual incidence rate per 1000 residents.

^b Simultaneous adjustment for all variables listed in table with clustering by facility.

^c Reference groups were residents without the condition.

^d Reference groups were residents without the device.