MAJOR ARTICLE

Factors Associated With *Candida auris* Colonization and Transmission in Skilled Nursing Facilities With Ventilator Units, New York, 2016–2018

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Background. *Candida auris* is an emerging, multidrug-resistant yeast that spreads in healthcare settings. People colonized with *C. auris* can transmit this pathogen and are at risk for invasive infections. New York State (NYS) has the largest US burden (>500 colonized and infected people); many colonized individuals are mechanically ventilated or have tracheostomy, and are residents of ventilator-capable skilled nursing facilities (vSNF). We evaluated the factors associated with *C. auris* colonization among vSNF residents to inform prevention interventions.

Methods. During 2016–2018, the NYS Department of Health conducted point prevalence surveys (PPS) to detect *C. auris* colonization among residents of vSNFs. In a case-control investigation, we defined a case as *C. auris* colonization in a resident, and identified up to 4 residents with negative swabs during the same PPS as controls. We abstracted data from medical records on patient facility transfers, antimicrobial use, and medical history.

Results. We included 60 cases and 218 controls identified from 6 vSNFs. After controlling for potential confounders, the following characteristics were associated with *C. auris* colonization: being on a ventilator (adjusted odds ratio [aOR], 5.9; 95% confidence interval [CI], 2.3–15.4), receiving carbapenem antibiotics in the prior 90 days (aOR, 3.5; 95% CI, 1.6–7.6), having ≥1 acute care hospital visit in the prior 6 months (aOR, 4.2; 95% CI, 1.9–9.6), and receiving systemic fluconazole in the prior 90 days (aOR, 6.0; 95% CI, 1.6–22.6).

Conclusions. Targeted screening of patients in vSNFs with the above risk factors for *C. auris* can help identify colonized patients and facilitate the implementation of infection control measures. Antimicrobial stewardship may be an important factor in the prevention of *C. auris* colonization.

Keywords. *Candida auris*; colonization; mechanical ventilation; skilled nursing facilities; multidrug-resistant organisms.

Candida auris is an emerging, multidrug-resistant yeast that causes invasive infections associated with high mortality [1]. *Candida auris* was first reported in 2009 [2] and has since been identified in over 30 countries on 6 continents [3]. It is listed as an urgent threat in the Center for Disease Control and Prevention's 2019 Antibiotic Resistance Threat Report [4], because it tends to be resistant to multiple classes of antifungals and can spread in healthcare settings, causing large, multifacility outbreaks. *Candida auris* appears to be able to spread readily in healthcare settings for 2 main reasons: it can colonize a patient's

skin and other body sites for prolonged periods, and it can contaminate and persist in the healthcare environment [5–7]. Colonization puts patients at risk for invasive infection; ~5–10% of known colonized patients develop invasive infections [8, 9]. Colonization, especially with the high organism burden found in many patients colonized with *C. auris*, also allows for shedding into the environment and transmission to others [10, 11]. Furthermore, quaternary ammonium compounds, a commonly used class of disinfectants, do not yield the target log reduction in *C. auris* for effective disinfection [12].

In June 2016, the Centers for Disease Control and Prevention released a clinical alert regarding *C. auris*, and the first US cases were reported within 1 month [13, 14]. By September 2016, 14 cases were identified in New York. By September 2018, 2 years later, the New York State Department of Health (NYSDOH) had identified 515 people in New York who were infected or colonized with *C. auris* [15]. Many of those infected or colonized were residents on ventilator units in skilled nursing facilities

(vSNFs) and had tracheostomies, often requiring mechanical ventilation and percutaneous gastrostomy tubes [16, 17]. Contact tracing and epidemiologic investigations surrounding cases earlier in the epidemic in New York revealed that the prevalence of *C. auris* colonization in vSNF units was nearly 10 times higher than the prevalence in skilled nursing facilities that did not provide care for ventilated residents [16]. Although *C. auris* cases are commonly detected in acute care hospitals and transmission has been documented to occur in those facilities, epidemiologic evidence—including the fact that most patients had resided in a high-acuity postacute care facility, such as a vSNF or long-term acute care hospital (LTACH) in the months before diagnosis with *C. auris*—suggests that the potential for transmission is considerable in these facilities. Infection control efforts to prevent transmission of multidrug-resistant organisms (MDROs) have historically focused primarily on acute care hospitals, but emerging evidence suggests that high-acuity postacute care facilities like vSNFs and LTACHs are important sources of MDRO transmission, in part because of the concentration of patients with severe underlying conditions, the prolonged lengths of stay, and fewer resources being allocated for infection control than in hospitals. LTACHs provide hospital-level care for patients requiring more than short-term hospitalization, including those with ongoing ventilator dependence; vSNFs provide nursing-level care, especially for those unable to be weaned off a ventilator even after an LTACH stay. Residents often transfer across an interconnected network of postacute care facilities and acute care hospitals, allowing for interfacility transmission of MDROs to shared populations; vSNFs and LTACHs can serve as amplifiers for MDRO spread throughout a region, as was seen in Chicago for carbapenem-resistant Enterobacteriaceae [18]. Because available evidence suggested that a substantial proportion of patients with *C. auris* in New York had received care in vSNFs (notably, New York has only 3 LTACHs), and information about *C. auris* in this population remains limited, we aimed to identify the factors associated with *C. auris* colonization in New York vSNFs to inform infection prevention measures.

METHODS

Settings and Study Design

Following detection of the first *C. auris* cases in 2016 and through 2018, the NYSDOH intensively tracked cases of *C. auris* infection identified during clinical care in New York, and conducted contact tracing at facilities where case residents resided in the 90 days before *C. auris* infection. To identify asymptomatic colonized people at affected facilities, given their contribution to transmission, the NYSDOH conducted point prevalence surveys (PPS), in which residents were swabbed in the nares, axilla, and groin. These PPS were conducted on units where the index person currently resided or had resided in the

previous 90 days. Swabs were sent to the New York State (NYS) Wadsworth Center Laboratory for *C. auris* polymerase chain reaction testing and culture, as previously described [11, 16]. The same swab was used for both tests. People with culture-positive swabs were considered screening cases. During August 2016–September 2018, a total of 104 PPS were conducted at 64 facilities, including 22 vSNFs.

Considering the ongoing transmission in NYS, we conducted a case-control investigation to assess the factors associated with *C. auris* colonization in vSNFs that met all of the following 3 criteria: at least 1 PPS conducted during August 2016–September 2018, at least 5 people with *C. auris* colonization identified on any of the surveys performed at the facility, and willingness to participate in the investigation. We chose facilities with at least 5 colonized people for ease of execution of the investigation. A case was defined as a resident of a selected New York vSNF who had *C. auris* colonization (ie, screening case; not active infection), as determined by a positive culture for *C. auris* from a PPS swab collected during August 2016–September 2018. The control group included residents of the same vSNFs, screened during the same PPS, who were not culture positive for *C. auris*. We included every case identified during a PPS and used a random number generator to select controls sampled on the same date until we had up to 4 times as many controls as cases for each PPS.

We reviewed medical records for cases and controls and abstracted data using a standardized case report form. We collected information on resident demographic characteristics, underlying conditions, functional status, use of antibacterial and antifungal medications 90 days before screening, devices (including mechanical ventilation and tracheostomy), history of MDRO infection or colonization, and room location history. We also collected data on healthcare facility transfers, including site of hospitalization, dates of admission and discharge at each healthcare facility, and total number of facility transfers in the 6 months before *C. auris* screening. All facilities were provided with infection control guidance that included recommendations for personal protective equipment, hand hygiene, and proper environmental disinfection. The degree to which the facilities implemented these recommendations varied, but we were unable to measure this on a numerical scale.

Variables and Definitions

A history of MDRO colonization was defined by a history of contact precautions in the previous 90 days for *Clostridioides difficile*, carbapenem-resistant Enterobacteriaceae, carbapenem-resistant *Pseudomonas aeruginosa*, carbapenem-resistant *Acinetobacter baumannii*, vancomycin-resistant *Enterococcus* spp., methicillin-resistant *Staphylococcus aureus* (MRSA), or extended-spectrum beta-lactamase producing bacteria. We used an age-adjusted Charlson comorbidity index to evaluate the severity of underlying conditions [19]. To assess functional

status, we used a modified Barthel index for activities of daily living (ADLs) [20]. We included personal hygiene, bathing, feeding, toileting, bowel control, bladder control, and chair/bed transfers, but did not include ambulation, stair climbing, and dressing, which are included in the original Barthel index, as these data were unavailable in medical records. Each of the ADLs was scored as fully independent, needs assistance, or unable to perform task. All-cause mortality was determined based on information abstracted from the electronic and facility records at 30 and 90 days.

We also collected data on roommate colonization status and proximity to other colonized residents. When a room occupancy history was available, we recorded which rooms were previously occupied by a colonized resident. We also recorded whether cases and controls resided in a room adjacent to a colonized resident's room. Adjacent was defined as sharing a wall with another room, and these data were only collected when facility floor maps were available to confirm room locations. Lastly, we recorded whether the resident resided in a single-, double-, triple-, or quadruple-occupancy room at the time of *C. auris* screening.

Statistical Analysis

Variables were assessed for associations using univariate and multivariable logistic regression. Risk factors and potential confounders included in the multivariable logistic regressions were selected using *a priori* information based on the use of directed acyclic graphs. These graphs were used to build estimated causal structures to determine potential confounders. Unadjusted odds ratios (ORs) and adjusted odds ratios (aORs) were calculated with 95% confidence intervals (CIs). All data were analyzed using SAS 9.4 (SAS Institute, Cary, NC).

RESULTS

Of the 45 vSNFs in the *C. auris*–affected areas of New York, 22 vSNFs had cared for *C. auris* cases within 90 days of diagnosis (48.9%); 8 of these vSNFs (17.8%) had ≥5 cases identified on PPS during August 2016–September 2018, but only 6 fit all criteria. All 6 were included in our investigation, encompassing 81% of surveillance cases identified by PPS in vSNFs where ≥5 cases were identified. The 6 included vSNFs had a median of 271 residential beds (range, 200–320) and 21 ventilator beds (range, 10–80). These 6 vSNFs included 11 units that could provide care for residents with advanced respiratory needs (range, 1–4 per facility).

Across these 6 vSNFs, 12 PPS were conducted, with 2 vSNFs having 3 PPS, 2 having 2 PPS, and 2 having a single PPS. Multiple PPS were prompted by the burden of colonization found on prior PPS or the detection of a clinical or surveillance case at an acute care facility with known passthrough to a given vSNF, as well as the facility's willingness to participate. The median prevalence of *C. auris* colonization on PPS was 12%

(range, 3–33%). These PPS identified 60 cases, allowing for the selection of 218 controls for the investigation (4 controls were not available for all cases). Residents in the case and control groups did not differ by age (median, 68.0 years [range, 26–97] for cases vs 69.5 years [range, 20–98] for controls; *P* = .771), sex (50.0% male for cases vs 47.2% male for controls; *P* = .702), or race/ethnicity (Table 1).

The underlying conditions did not differ between cases and controls, although multiple conditions were common in both groups. Most had neurologic disease (81.7% in cases vs 73.4% in controls; *P* = .190), and about half had cardiovascular disease (50.0% vs 57.8%, respectively; *P* = .283) and diabetes (41.7% vs 39.9%, respectively; *P* = .807). Similarly, Charlson comorbidity index scores did not differ between groups (mean, 5.33 [interquartile range {IQR}, 4–7] in cases vs 5.56 [IQR, 4–7] in controls; *P* = .543). Overall, both groups had minimal ability to perform ADLs, with median Barthel index scores of 0 [range, 0–10 in cases vs 0–60 in controls].

Both cases and controls often had medical devices (100% of cases vs 89.0% of controls), but the presence of certain devices was associated with *C. auris* colonization, including tracheostomy (96.7% vs 82.1%, respectively; OR, 11.33; 95% CI, 2.1–60.8), mechanical ventilation (88.3% vs 63.3%, respectively; OR, 5.62; 95% CI, 2.2–14.2), percutaneous gastrostomy or jejunostomy tubes (93.3% vs 82.6%, respectively; OR, 3.04; 95% CI, 1.0–9.2), and indwelling urinary catheters (40.0% vs 18.8%, respectively; OR, 3.43; 95% CI, 1.8–6.7). A history of MDRO colonization was also more common among cases than controls (43.3% vs 24.3%, respectively; OR, 2.58; 95% CI, 1.4–4.9). The 90-day all-cause mortality rate was higher among cases (16.7%) than controls (4.1%).

Antibacterial use in the 90 days before *C. auris* screening was more common among cases than controls, with cases receiving a median of 3 (IQR, 1–5) courses of systemic antibacterial drugs, compared with 1 course (IQR, 0–3) among controls (OR, 1.34; 95% CI, 1.2–1.5; Table 2). The most commonly prescribed antibacterial drugs were carbapenems (43.3% of cases vs 16.1% of controls; *P* < .01), vancomycin (41.7% vs 21.6%, respectively; *P* < .01), levofloxacin (15.0% vs 17.9%, respectively; *P* = .602), cefepime (15.0% vs 10.6%, respectively; *P* = .341), and piperacillin/tazobactam (13.3% vs 10.6%, respectively; *P* = .546). Receipt of carbapenems (OR, 4.68; 95% CI, 2.4–9.2) and receipt of vancomycin (OR, 2.71; 95% CI, 1.4–5.1) in the 90 days before PPS were associated with *C. auris* colonization. Receipt of systemic antifungals was uncommon in both cases and controls (11.7% vs 6.4%, respectively; *P* = .175). In both cases and controls, the most commonly prescribed antifungals were fluconazole (11.7% vs 3.2%, respectively; *P* = .008) and nystatin (0% vs 4.6%, respectively; *P* = .092). Receipt of fluconazole in the 90 days before PPS was associated with *C. auris* colonization (OR, 4.21; 95% CI, 1.4–12.9).

Table 1. Comparison of Clinical Characteristics Between Patients Colonized With *Candida auris* and Patients With Negative *C. auris* Screening Swabs

Clinical characteristics	Case, n = 60, n (%)	Control, n = 218, n (%)	Odds ratio[a] (95% CI)
Demographics			
Male, n_{case} = 60; $n_{control}$ = 214	30 (50.0)	101 (47.2)	1.12 (.62–2.02)
Age, median (range)	68.0 (26–97)	69.5 (20–98)	1.00 (.98–1.02)
Race/ethnicity, n_{case} = 58; $n_{control}$ = 192			
White, non-Hispanic	25 (43.1)	72 (37.5)	Ref
Black, non-Hispanic	17 (29.3)	62 (32.3)	.78 (.38–1.60)
Asian, non-Hispanic	9 (15.5)	34 (17.7)	1.81 (.31–2.13)
Hispanic	6 (10.3)	23 (12.0)	.83 (.27–2.52)
Other, non-Hispanic	1 (1.7)	1 (.5)	2.97 (.17–50.64)
BMI, n_{case} = 55; $n_{control}$ = 197			
Underweight	5 (9.1)	16 (8.1)	1.08 (.33–3.54)
Normal	23 (41.8)	73 (37.1)	Ref
Overweight	13 (23.6)	62 (31.5)	.65 (.30–1.43)
Obese	14 (25.5)	46 (23.4)	.98 (.44–2.18)
Clinical characteristics			
Diabetes	25 (41.7)	87 (39.9)	1.05 (.58–1.91)
Neurologic disease[b]	49 (81.7)	160 (73.4)	1.61 (.77–3.38)
Dementia	21 (35.0)	63 (28.9)	1.35 (.72–2.55)
Cardiovascular disease[c]	30 (50.0)	126 (57.8)	.69 (.38–1.27)
Myocardial infarction	2 (3.3)	12 (5.5)	.56 (.12–2.73)
Congestive heart failure	18 (30.0)	50 (22.9)	1.46 (.74–2.91)
Peripheral vascular disease	5 (8.3)	10 (4.6)	2.10 (.64–6.84)
Cerebrovascular attack	17 (28.3)	88 (40.4)	.55 (.29–1.05)
Chronic kidney disease	7 (11.7)	26 (11.9)	.95 (.38–2.37)
Mild liver disease[d]	1 (1.7)	5 (2.3)	.71 (.08–6.33)
Hemiplegia/paraplegia/quadriplegia	5 (8.3)	40 (18.3)	.36 (.13–1.02)
CCI with age, median (IQR)	5.33 (4–7)	5.56 (4–7)	.95 (.84–1.08)
Modified Barthel index, median (range), n_{case} = 47; $n_{control}$ = 184	0 (0–10)	0 (0–60)	.84 (.70–1.01)
Medical devices present	60 (100.0)	194 (89.0)	N/A
Tracheostomy	58 (96.7)	179 (82.1)	11.33 (2.11–60.77)
Mechanical ventilation	53 (88.3)	138 (63.3)	5.62 (2.22–14.23)
Surgically placed feeding tube	56 (93.3)	180 (82.6)	3.04 (1.01–9.19)
Urinary catheter	24 (40.0)	41 (18.8)	3.43 (1.75–6.70)
Central venous catheter	5 (8.3)	6 (2.8)	3.31 (.93–11.83)
Any MDRO in the 90 days prior to PPS[e]	26 (43.3)	53 (24.3)	2.58 (1.36–4.89)
Clostridioides difficile	10 (16.7)	18 (8.3)	2.29 (.98–5.40)
Methicillin-resistant *Staphylococcus aureus*	8 (13.3)	16 (7.3)	1.93 (.76–4.89)
Carbapenem-resistant Enterobacteriaceae	5 (8.3)	6 (2.8)	3.52 (.99–12.52)
ESBL-producing bacteria	4 (6.7)	10 (4.6)	1.58 (.46–5.37)
Vancomycin-resistant *Enterococcus* spp.	4 (6.7)	3 (1.4)	5.06 (1.06–24.21)
Carbapenem-resistant *Pseudomonas aeruginosa*	3 (5.0)	6 (2.8)	1.86 (.42–8.15)
Carbapenem-resistant *Acinetobacter baumannii*	1 (1.7)	4 (1.8)	.95 (.10–9.27)
Mortality			
90-day all-cause mortality	10 (16.7)	9 (4.1)	4.80 (1.79–12.89)
30-day all-cause mortality	3 (5.0)	5 (2.3)	2.21 (.49–9.96)

Abbreviations: BMI, body mass index; CCI, Charlson comorbidity index; CI, confidence interval; ESBL, extended-spectrum beta-lactamase; IQR, interquartile range; MDRO, multidrug-resistant organism; PPS, point prevalence survey.

[a]Univariate models used to calculate odds ratios included PPS in the models.

[b]Neurologic disease includes cerebral palsy, chronic cognitive deficit, dementia, epilepsy, seizure disorders, multiple sclerosis, neuropathy, Parkinson's disease, and others.

[c]Cardiovascular disease includes cerebrovascular attack, stroke, transient ischemic attack, congenital heart disease, congestive heart failure, myocardial infarction, and others.

[d]Mild liver disease includes cirrhosis without portal hypertension and chronic hepatitis.

[e]Any MDRO includes *Clostridioides difficile*, carbapenem-resistant Enterobacteriaceae, carbapenem-resistant *Pseudomonas aeruginosa*, carbapenem-resistant *Acinetobacter baumannii*, vancomycin-resistant *Enterococcus* spp., methicillin-resistant *Staphylococcus aureus*, or ESBL-producing bacteria, as well as coinfections with multiple MDROs. Due to coinfections, the sum of specific MDROs exceeds the number of individuals with any MDRO.

Cases more frequently had ≥1 transfer to an acute care hospital in the 6 months before *C. auris* screening than did controls (81.0% vs 56.3%, respectively; OR, 3.53; 95% CI, 1.7–7.4).

Lastly, we analyzed whether roommates or room location were associated with *C. auris* colonization. Among residents with room location data available (n_{case} = 59; $n_{control}$ = 200), the

Table 2. Antibacterial Use, Antifungal Use, Acute Care Hospitalizations Prior to Point Prevalence Survey, and Roommate Analyses in *Candida auris* Colonized Cases and Controls, New York, 2016–2018

Drug or hospital exposure	Case, n = 60	Control, n = 218	Odds ratio[a] (95% CI)
Antibiotic use, median (IQR)			
Total antibiotic courses in the 90 days before PPS	3 (1–5)	1 (0–3)	1.31 (1.15–1.49)
Systemic antibiotic courses in the 90 days before PPS	3 (1–5)	1 (0–3)	1.34 (1.16–1.54)
Received any antibiotic in the 90 days before PPS, n (%)	51 (85.0)	152 (69.7)	2.75 (1.24–6.11)
≥1 systemic antibiotic in the 90 days before PPS, n (%)	48 (80.0)	139 (63.8)	2.51 (1.22–5.17)
Specific antibacterial drugs used in the 90 days before PPS, n (%)			
Received vancomycin or a carbapenem	36 (60.0)	64 (29.4)	4.30 (2.24–8.27)
Carbapenems	26 (43.3)	35 (16.1)	4.68 (2.38–9.21)
Vancomycin	25 (41.7)	47 (21.6)	2.71 (1.44–5.10)
Levofloxacin	9 (15.0)	39 (17.9)	.82 (.36–1.84)
Cefepime	9 (15.0)	23 (10.6)	1.58 (.66–3.75)
Piperacillin/tazobactam	8 (13.3)	23 (10.6)	1.31 (.55–3.15)
Antifungal use, median (IQR)			
Total antifungal courses in the 90 days before PPS	0 (0–1)	0 (0–1)	.79 (.52–1.19)
Systemic antifungal courses in the 90 days before PPS	0 (0–0)	0 (0–0)	1.48 (.81–2.71)
≥1 systemic antifungal in the 90 days before PPS, n (%)	7 (11.7)	14 (6.4)	2.11 (.77–5.80)
Specific antifungal drugs used in the 90 days before PPS, n (%)			
Fluconazole	7 (11.7)	7 (3.2)	4.21 (1.37–12.94)
Nystatin	0 (0)	10 (4.6)	.37 (.02–2.29)[b]
ACH visits, median (IQR)			
Total ACH visits in the 6 months before PPS	1 (1–3)	1 (0–2)	1.29 (1.07–1.56)
Multi-day ACH visits in the 6 months before PPS	1 (1–2)	1 (0–1)	1.48 (1.18–1.85)
≥1 ACH visits in the 6 months before PPS, n (%)	47 (81.0)	112 (56.3)	3.53 (1.69–7.41)
Roommate colonization status, n_{case} = 59; $n_{control}$ = 200			
Room with a colonized roommate	4 (6.8)	27 (13.5)	.44 (.14–1.33)
Room type at time of screening,[c] n_{case} = 57; $n_{control}$ = 198			
In a room with 1 bed	8 (14.0)	28 (14.1)	Ref
In a room with 2 beds	42 (73.7)	151 (76.3)	1.00 (.41–2.43)
In a room with 4 beds	7 (12.3)	19 (9.6)	1.46 (.42–5.01)

Abbreviations: ACH, acute care hospital; CI, confidence interval; IQR, interquartile range; PPS, point prevalence survey.

[a]Univariate models used to calculate odds ratios included PPS in the models.

[b]Calculated with a Haldane-Anscombe correction.

[c]There were no rooms containing 3 beds.

odds of having a roommate colonized with *C. auris* at the time of the PPS were similar among cases and controls (OR, 0.44; 95% CI, .1–1.3). We only found 2 rooms that housed multiple residents colonized with *C. auris* concurrently. Among residents with room type data available (n_{case} = 57; $n_{control}$ = 198), the odds of *C. auris* colonization were similar between residents staying in single-occupancy rooms and residents staying in double-occupancy (OR, 1.00; 95% CI, .4–2.4) or quadruple-occupancy rooms (OR, 1.46; 95% CI, .4–5.0). None of the facilities had triple-occupancy rooms. Examples of the maps used to generate the data for these analyses are depicted in the maps in Figure 1 for Facility A, for which the most complete data were available for analyses.

In multivariable logistic regression analyses, compared with controls, cases were more likely to be mechanically ventilated (aOR, 5.88; 95% CI, 2.3–15.4), to have been hospitalized in the 6 months before screening (aOR, 4.23; 95% CI, 1.9–9.6), to have received carbapenems in the 90 days before screening

(aOR, 3.52; 95% CI, 1.6–7.6), and to have received fluconazole in the 90 days before screening (aOR, 6.0; 95% CI, 1.6–22.6; Table 3).

DISCUSSION

In NYS and other states with *C. auris* outbreaks, high-acuity postacute care facilities, like vSNFs, care for a disproportionate number of *C. auris* cases, and in this population of vulnerable individuals, the risk of transmission is high. This investigation identified specific invasive medical devices, recent antimicrobial use, recent hospitalization, and colonization with other MDROs as resident-level risk factors associated with *C. auris* colonization in vSNFs. The risk factors for *C. auris* colonization closely resemble many of those for other MDROs, like carbapenemase-producing organisms, which are also a major problem in high-acuity postacute care facilities. For example, in Orange County, California, LTACHs were found to have an 80% prevalence of
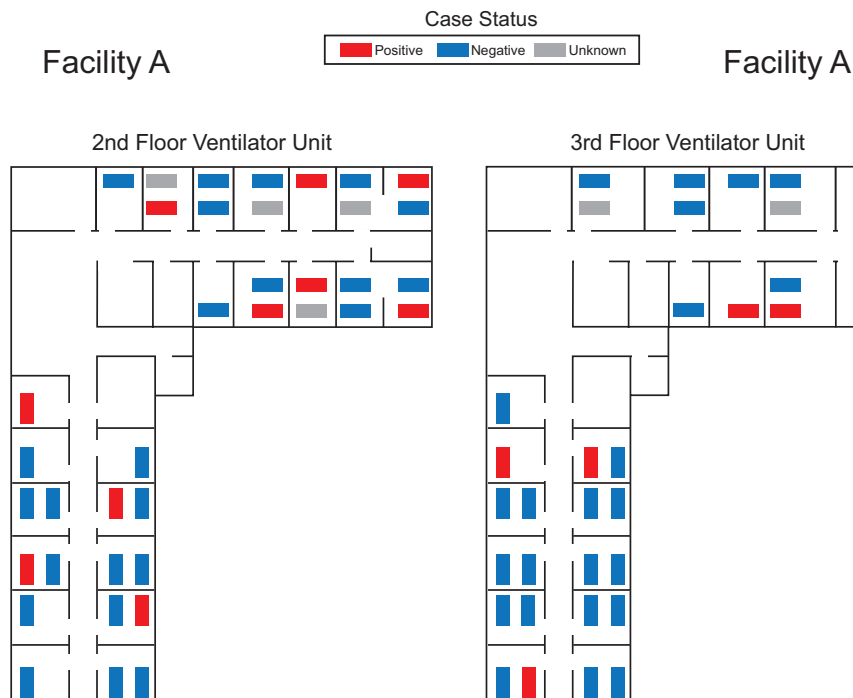
Figure 1. Facility maps depicting the *Candida auris* colonization status and location of patients at the time of a single point prevalence survey in the ventilator unit of a skilled nursing facility, New York, 2016–2018.

MDROs [21]. Similarly, in Chicago, 40% of vSNF residents were colonized with carbapenemase-producing organisms, and these facilities likely served as reservoirs of transmission to other facilities [22]. Like these organisms, the prevalence of *C. auris* has exceeded 50% in certain Chicago vSNFs and has reached 33% in some New York vSNF units [17, 23].

Our study underscores the importance of targeting infection prevention measures to facilities that care for chronically ventilated residents as part of a regional approach for containment of novel, resistant pathogens, particularly given the high level of MDRO co-colonization and frequent hospitalizations. The early identification of people with *C. auris* infection or colonization is key to controlling spread, and this investigation and others suggest that vSNF and LTACH populations are often high-yield sites for early-detection interventions. Admission and discharge screening at acute care hospitals could be considered for patients being admitted from or discharged to vSNFs or LTACHs in areas with known *C. auris* cases. Admission screening in vSNFs may be challenging because of limited staff to perform screenings and lower capacities for packaging and shipping of specimens, while admission screening in LTACHs may be more feasible. Early *C. auris* detection can allow for the targeted implementation of basic infection control measures, such as hand hygiene, transmission-based precautions, effective environmental cleaning and disinfection, and the development of cohorted areas with designated staff to care for affected patients

in order to limit transmission. Communication between facilities about residents' *C. auris* colonization status is also essential in ensuring receiving facilities implement proper precautions.

Just as antibiotic use is a risk factor for MDRO colonization and other *Candida* infections, we observed an association between broad-spectrum antibacterial use and *C. auris* colonization [24–27]. While vancomycin was found to be associated with colonization, it is worth noting that this drug is often given in combination with antibiotics with Gram-negative coverage, which have been proven to disrupt the gut microbiome [28–30]. Systemic antibacterial use can lead to intestinal *Candida* overgrowth [31]; similarly, broad-spectrum antibiotic use may disrupt the skin microbiome, and the potential selection pressure exerted by use of fluconazole, a drug most *C. auris* isolates are resistant to, may facilitate *C. auris* colonization. Further study of the skin microbiome is needed, including of the role of the fungal mycobiome and impacts of antimicrobial use. Antimicrobial stewardship, an important part of any medical care, may be useful in reducing the risk of *C. auris* colonization.

A notable finding from this investigation was the lack of association between a resident's *C. auris* colonization status and the number of beds in a room or the colonization status of roommates. These findings are similar to those for MRSA transmission, in which roommates accounted for only a small portion of the risk of MRSA acquisition [32]. Unlike influenza or group A *Streptococcus*, for which roommates are at the greatest risk,

Table 3. Multivariable Logistic Regression Models for Assessing Factors for Association With *Candida auris* Colonization, New York, 2016–2018

Factors	aOR	95% Confidence Interval Lower	95% Confidence Interval Upper
Mechanically ventilated[a]	5.88	2.25	15.37
Any ACH visit in the 6 months prior to PPS[b]	4.23	1.87	9.60
Received a carbapenem in the 90 days prior to PPS[c]	3.52	1.62	7.63
Received systemic fluconazole in the 90 days prior to PPS[d]	5.98	1.58	22.64
Received vancomycin in the 90 days prior to PPS[e]	1.65	.75	3.67
Any MDRO in the 90 days prior to PPS[f]	1.25	.56	2.76
Room with a colonized roommate[g]	.37	.12	1.16
Room type at time of screening[h]			
In a room with 1 bed	Ref	Ref	Ref
In a room with 2 beds	1.44	.55	3.80
In a room with 4 beds	2.04	.54	7.70

Abbreviations: ACH, acute care hospital; aOR, adjusted odds ratio; CCI, Charlson comorbidity index; MDRO, multidrug-resistant organism; PPS, point prevalence survey.

[a]The model for mechanical ventilation includes race/ethnicity, sex, age, and CCI.

[b]The model for ACH visits includes race/ethnicity, sex, age, CCI, and body mass index.

[c]The model for receipt of a carbapenem includes race/ethnicity, sex, age, CCI, ACH visits, and presence of a urinary catheter.

[d]The model for receipt of systemic fluconazole includes race/ethnicity, sex, age, CCI, and ACH visits.

[e]The model for receipt of vancomycin includes race/ethnicity, sex, age, CCI, ACH visits, and presence of a urinary catheter.

[f]The model for MDROs includes race/ethnicity, sex, age, CCI, ACH visits, and receipt of broad-spectrum antibiotics.

[g]The model for rooming with a colonized roommate includes presence of an MDRO in the 90 days prior to PPS, sex, and mechanical ventilation.

[h]The models for room type include the presence of an MDRO in the 90 days prior to PPS, sex, and mechanical ventilation.

MRSA acquisition risk is not limited to roommates [33, 34]. While a ventilator-dependent resident who recently returned from a hospital after receiving broad-spectrum antibiotics and who shares a room with a resident colonized with *C. auris* is likely at risk for acquiring *C. auris* colonization due to proximity to another colonized resident and having the risk factors for colonization, the risk of colonization is not limited to these roommates alone. The finding that cases may be distributed in an entire unit underscores the need to look at a unit level when defining the potential group at risk when facilities attempt to control this pathogen. Potential explanations for these findings include contamination of mobile medical equipment and inadequate environmental disinfection [6, 7, 11, 35, 36]. Using dedicated medical equipment for each resident, conducting meticulous cleaning and disinfection with appropriate products, and adhering to proper hand hygiene and personal protective equipment use when indicated may be important in preventing transmission on these wards [8, 14].

There were several additional limitations to this study. First, because PPS occurred at specific points in time, we did not know how long before positive tests residents became colonized with *C. auris*. Therefore, we may have misattributed some exposures as occurring before colonization when they in fact occurred after. Colonization may also have occurred at other facilities, such as hospitals. Medical records rarely contained start and end dates for antimicrobials, and we were unable to determine days of therapy nor examine a dose-response relationship between use and colonization. We acknowledge that longitudinal data on the colonization status and location of roommates were limited. Our results were based on the roommate's colonization status at the time of the PPS because longitudinal roommate colonization data were rarely available, so cases may have shared a room with other colonized residents whose colonization status was not yet known or whose room location history was not available. In addition, quadruple-occupancy rooms on the ventilator-capable units were less common than double and single rooms in these facilities, which might be different in other postacute care facilities, including those outside NYS. This investigation focused primarily on resident-level factors, whereas facility-level factors, including infection prevention and control measures, likely also play a strong role in the transmission of *C. auris* and other MDROs. Facility-level factors are more difficult to assess from medical records, and likely changed over time as interventions were implemented in response to *C. auris* cases.

Residents in vSNFs and other high-acuity postacute care settings are at increased risk for colonization with *C. auris* and other MDROs, and this can allow for amplification through a healthcare network. In our investigation, the odds of *C. auris* colonization differed with the prevalence of invasive devices, exposure to broad-spectrum antibiotics, receipt of fluconazole, and recent hospitalizations, but not with being a roommate of a resident with *C. auris*. As such, contact tracing for *C. auris* should potentially consider the entire unit at risk, and assessment for colonization should extend beyond roommates. Interventions that may mitigate spread include admission and discharge screening in facilities where it is feasible, discharge screening from acute care hospitals, interfacility communication about MDRO status upon transfer, and robust infection control efforts. Given the elevated prevalence of MDROs, including *C. auris*, in some high-acuity postacute care facilities, a better understanding of practical ways to prevent transmission, including bolstering the basics of infection prevention and novel strategies beyond the basics in these settings, is urgently needed to reduce the spread of these MDROs through the broader healthcare system.

Notes

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