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Risk Factors Associated With Progression to Clinical *Candida auris* Infection Among Adults With Previous Colonization—Florida, 2019–2023

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Abstract

Background. *Candida auris* is an emerging fungal organism that has caused outbreaks in healthcare settings and become a major public health concern, particularly among medically vulnerable populations.

Methods. Using a retrospective case-control design, we investigated factors associated with *C. auris* clinical cases after prior colonization among patients identified in Florida healthcare facilities during 1 January 2019–31 December 2023.

Results. We identified 105 case-patients with documented clinical specimens after colonization and 578 control subjects with colonization only. Factors significantly associated with clinical cases included presence of ≥ 5 comorbid conditions (odds ratio [OR], 10.02 [95% confidence interval {CI}, 4.07–24.7]), ≥ 4 invasive devices (OR, 2.92 [95% CI, 1.70–5.03]), or ≥ 3 recent medical procedures (OR, 2.32 [95% CI, 1.19–4.55]). In addition, fully dependent care required for eating

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Author contributions. K. E. S., A. Ch., T. J. D., I. H., and C. B. conceived the study idea and developed the study design. K. E. S., J. R., G. C., A. Co., and J. E. performed case finding and data collection steps, reviewed medical records, and/or performed quality control and assurance. K. E. S., T. J. D., and I. H. designed the database, worked out technical details, and carried out the analysis. K. E. S., A. Ch., J. R., G. C., T. J. D., and I. H. contributed to the interpretation of the results. A. Ch., T. J. D., and C. B. provided administrative, logistical, and supervisory support. K. E. S. and A. Ch. took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis, and manuscript.

Disclaimer.

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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(OR, 2.80), mobility (OR, 2.15), and transferring (OR, 1.82) were associated with clinical case progression.

Conclusions. We found a significant association with progression from screening colonization to clinical *C. auris* cases among patients with multiple comorbidities, invasive devices, recent invasive procedures, and poor functional status. Identifying risk factors for clinical progression of *C. auris* after colonization could enable facilities to implement efficient testing protocols and infection prevention and control measures to help prevent morbidity associated with invasive infections.

Keywords

Candida auris ; emerging fungal infections; infection prevention and control; hospital epidemiology; colonization

Candida auris is an emerging fungal organism that has caused outbreaks in healthcare settings and has become a major public health concern, particularly among medically vulnerable populations [1]. *Candida auris* is often resistant to multiple antifungal drugs used to treat *Candida* infections [1]. *Candida auris* can colonize persons asymptomatically or cause severe systemic infections [2]. Patients colonized with *C. auris* have a higher risk for bloodstream infections, which have been associated with 30-day all-cause mortality of 40% or greater [3]. Studies have demonstrated a high burden of *C. auris* on the skin of colonized patients and presence on high-touch surfaces and equipment in the healthcare environment, indicating a high risk for transmission within facilities [4–7].

Why some *C. auris* patients experience clinical signs and symptoms, whereas others remain colonized without progression to clinical infection, is not fully understood. Multiple studies have identified risk factors for acquiring *C. auris* colonization or infection as a discrete event but have been limited by small sample size or conducted only in intensive care settings [8–12]. Retrospective cohort studies outside of the United States (US) have identified risk factors for candidemia and mortality [13, 14]. Individual risk factors identified have included chronic medical conditions, including diabetes, cardiovascular disease, advanced chronic kidney disease, and neurologic disease [7, 10, 14–17]. A multicenter cohort study with patients from Florida and California identified significant association of Pitt bacteremia severity scores and receipt of hemodialysis with poor outcomes among patients with *C. auris* bacteremia [18].

Few studies examine statewide or multifacility data to determine risk factors for *C. auris* progression following colonization in various care settings [19]. Certain studies have identified epidemiologic trends with patients' multiple healthcare exposures across facility types, particularly long-term acute care hospitals (LTACHs) and ventilator-equipped skilled nursing facilities (SNFs) [15, 20–23]. A literature review found scant data regarding the association of patients' functional status with progression to *C. auris* infection [18, 20]. Understanding the effects of patients' level of dependency in association with infection caused by *C. auris* can more fully guide care management and earlier interventions to mitigate risk for clinical illness. Knowledge of the factors associated with progression to clinical infection can be used to improve facility testing protocols, healthcare provider

knowledge, and infection prevention and control (IPC) measures to improve patient outcomes.

Candida auris clinical cases have been nationally notifiable since 2018 [24]. The burden of *C. auris* in the US has increased in the past few years, attributable to improved identification of cases and lapses in IPC measures [24]. The first *C. auris* infection in Florida was identified in 2017 and by the end of 2023, approximately 4000 patients colonized or infected with *C. auris* had been identified from Florida healthcare facilities. Although individual *C. auris* cases are not yet reportable conditions in Florida, outbreaks in healthcare facilities are reportable to the Florida Department of Health (FDOH). We sought to determine factors associated with the progression to clinical *C. auris* cases among patients previously colonized with *C. auris* in Florida during 2019–2023.

METHODS

Setting and Study Design

We used a retrospective case-control methodology to investigate factors associated with *C. auris* clinical cases among a population of colonized *C. auris* patients identified in Florida healthcare facilities during 1 January 2019–31 December 2023. We analyzed statewide disease reports of *C. auris* screening colonizations and clinical cases, submitted to FDOH by various healthcare facilities including acute care hospitals (ACHs), LTACHs, SNFs, and other long-term-care facilities. All adult Florida residents aged ≥ 18 years with ≥ 1 screening result positive for *C. auris* during the study period and medical record documentation in Florida's electronic disease reporting system (Merlin) were considered for inclusion in the analysis. Control subjects were defined as persons with a positive *C. auris* culture or polymerase chain reaction (PCR) result from a screening specimen (ie, axilla or groin skin swab) and no evidence of *C. auris* in clinical specimens during the study period, based on review of case report forms (CRFs) (screening vs clinical) and electronic laboratory reporting (ELR). All patients had been screened through contact tracing, point prevalence screening, admission screening, or by other active surveillance based on individual facility protocols. Control subjects were excluded if they had record of a positive screening swab followed by a negative screening swab [25]. Case-patients were defined as patients with confirmed *C. auris* in culture or positive PCR test results from a clinical specimen (ie, urine, respiratory tract, blood, wound, or other body fluid) [26], documented clinical infection, and a history of *C. auris* colonization by positive screening specimen (ie, axilla or groin skin swab) ≥ 24 hours before clinical specimen collection. Patients with clinical specimens but without laboratory evidence of prior *C. auris* colonization (ie screening) were excluded. Persons with a positive *C. auris* culture but negative PCR results in a screening specimen were excluded unless a more recent positive screening laboratory result was also present.

Data available for case-patients and control subjects included demographic and clinical data from medical records, standardized CRFs, electronic laboratory results, and mortality status, which had been obtained from healthcare facilities and uploaded into Merlin. ELR provided up-to-date laboratory results from participating laboratories (state and commercial) and the Centers for Disease Control and Prevention's (CDC) Antimicrobial Resistance Laboratory Network. Data were collected from a statewide surveillance effort funded through CDC's

Epidemiology and Laboratory Capacity cooperative agreement. We reviewed all available documentation for case-patients and control subjects in Merlin to abstract data regarding patient demographic characteristics, medical comorbidities, presence of invasive devices, medical procedures, individual scores on activities of daily living (ADLs), history of infection or colonization with another multidrug-resistant organism (MDRO), room type, and healthcare facility admissions and transfers. If CRFs were missing or incomplete, we conducted abstraction of available medical records to collect variables of interest.

Variables and Definitions

The primary outcome variable, presence of *C. auris* in clinical specimens after colonization, was binary (ie, present or absent). The number of medical comorbidities reported on admission was grouped as 0–1, 2–4, or ≥ 5 to characterize increased morbidity [27]. The number of invasive medical devices in the 7 days before *C. auris* testing was categorized as 0–1, 2–3, or ≥ 4 . Due to low sample size for patients with zero comorbidities or invasive devices, the occurrence of “0” and “1” were combined for each of these variables. The number of medical procedures or services the patient underwent during the 7 days before testing was categorized as 0, 1–2, or ≥ 3 . Physical therapy was analyzed separately and not included in the enumeration of medical services because it is less invasive than surgery or medical procedures, such as dialysis. A history of other MDROs was defined as infection or colonization during the 90 days before positive *C. auris* screening. We also collected data regarding patient room occupancy at the time of admission (single occupancy or roomed with other patients). We used a binary measure for >1 healthcare facility admission or transfer during the 12 months before screening. All-cause mortality for cases and controls was determined by matching to the Florida death registry at 30 and 90 days after initial positive *C. auris* screening.

To assess functional status, we used a modified index of ADLs recorded on the CRF [28–30]. Each ADL category was scored on a scale from 1 to 5, where 1 = no supervision needed, 3 = continual help needed, and 5 = completely dependent. Assessment areas included eating, mobility, transferring, and toileting. If not documented on the CRF, ADLs were determined through medical record abstraction. If gastrointestinal feeding tube or total parenteral nutrition (TPN) was documented, the patient was assigned a score of 5 for the eating ADL. If an indwelling urinary catheter was documented, the patient was assigned a 5 in toileting ADL. If using mechanical ventilation, the patient was assigned a 5 in transfer and mobility ADLs. In the case-control analysis, ADL scores <5 were considered as the reference group [31].

Statistical Analysis

We used χ^2 or Fisher exact test, as appropriate, to assess associations between case status as the primary outcome variable and clinical and demographic variables of interest. Unadjusted odds ratios (ORs) were calculated with 95% confidence intervals (CIs). All data cleaning and modeling procedures were performed with SAS version 9.3 (SAS Institute, Cary, North Carolina, USA) and R version 4.3.1 (R Foundation for Statistical Computing, Vienna, Austria) software.

This analysis was approved by FDOH's Ethics and Human Research Protection Program. This activity was reviewed by CDC, deemed not research, and was conducted consistent with applicable federal law and CDC policy (45 Code of Federal Regulations [C.F.R.] part 46.102(l)(2), 21 C.F.R. part 56; 42 United States Code [U.S.C.] section 241(d); 5 U.S.C. section 552a; 44 U.S.C. section 3501 et seq.).

RESULTS

During the study period, 4778 patients were colonized with *C. auris* or diagnosed with *C. auris* in a clinical specimen in Florida (Supplementary Figure 1). We reviewed records from 1073 unique patients eligible for inclusion (Figure 1). Of those reviewed, 137 patients met the clinical case definition and 32 were excluded for missing medical records or CRFs, leaving 105 case-patients for inclusion in the analysis. Of the eligible control subjects ($n = 635$), 57 were excluded for missing medical records or CRFs, leaving 578 for inclusion.

A total of 63 (60.0%) case-patients and 317 (54.8%) control subjects were male (Table 1). A greater proportion of case-patients were aged 50–64 years (39.0% vs 25.3%) and a lower proportion were aged ≥ 80 years (9.5% vs 18.2%), compared with control subjects. Median age was 64 years (range, 25–93 years) for case-patients and 69 years (range, 19–101 years) for control subjects. Case-patients and control subjects were similar with regard to race and ethnicity. Case-patients and control subjects mostly identified as White, non-Hispanic at 39% ($n = 41$) and 44% ($n = 256$), respectively. Of the 105 case-patients, 59 (56.2%) had laboratory-confirmed *C. auris* bloodstream infections (ie candidemia). Patients first screened positive for *C. auris* in various healthcare settings, including ACHs ($n = 382$ [56%]), LTACHs ($n = 287$ [42%]), SNFs and long-term care facilities ($n = 13$ [2%]), and inpatient rehabilitation facilities ($n = 1$ [0.15%]). The median time from first positive screening (colonization) to progression to clinical specimens based on laboratory collection dates was 91.3 days (range, 1–774 days). Although 30-day all-cause mortality was higher among control subjects (13.8%) than case-patients (3.8%), 90-day all-cause mortality was similar among case-patients (20.0%) and control subjects (19.6%) (OR, 1.03 [95% CI, .61–1.73]; $P = .91$).

Unadjusted measures revealed that case-patients had greater odds of being in the age group 50–64 years when compared to control subjects (OR, 1.77 [95% CI, 1.09–2.87]; $P = .0195$) (Table 2). The majority of case-patients (100%) and control subjects (95%) had at least 1 medical comorbidity documented. Presence of a neurologic condition was higher among case-patients (52.4%) compared to control subjects (36.7%) (OR, 1.90 [95% CI, 1.25–2.89]; $P = .002$). Chronic kidney disease was also significantly associated with clinical cases (OR, 2.12 [95% CI, 1.39–3.23]; $P = .0004$). Most case-patients and control subjects had at least 1 invasive medical device (89.5% of case-patients vs 84.4% of control subjects). Certain medical devices were more likely to be associated with clinical cases, including tracheostomy (OR, 2.09 [95% CI, 1.37–3.18]; $P = .0005$), mechanical ventilation (OR, 1.90 [95% CI, 1.24–2.92]; $P = .003$), and gastrointestinal feeding tube (OR, 1.94 [95% CI, 1.25–3.02]; $P = .003$). Of note, the presence of ≥ 4 invasive devices (OR, 2.92 [95% CI, 1.70–5.03]; $P < .0001$) was significantly associated with a *C. auris* clinical case. Central venous catheters were not significantly associated with clinical cases (OR, 1.37 [95% CI,

.90–2.08]; $P = .14$). Recent medical procedures were common among both case-patients and control subjects (78.1% and 73.2%, respectively). Case-patients had greater odds of a recent bronchoscopy (OR, 3.29 [95% CI, 1.41–7.66]; $P = .004$) and ≥ 3 procedures (OR, 2.32 [95% CI, 1.19–4.55]; $P = .012$). A previous MDRO infection or colonization was also more common among case-patients than control subjects (48.6% vs 29.1%, respectively; OR, 2.09 [95% CI, 1.32–3.31]; $P = .001$). No significant difference was found between case-patients (12.4%) and control subjects (15.1%) who shared a room (OR, 0.73 [95% CI, .39–1.37]; $P = .33$). Both case-patients (73.3%) and control subjects (68.2%) commonly had >1 healthcare facility admission during the year before testing positive for *C. auris* colonization, with no significant difference between groups (OR, 1.28 [95% CI, .81–2.05]; $P = .29$).

ADL scores were assessed separately for each category in eating, mobility, transferring, and toileting tasks (Table 2). Both case-patients and control subjects were likely to be assessed as fully dependent (ie, unable to complete self-care tasks) in each of these areas. Tube feeding or TPN (eating ADL score of 5) (75.2% vs 54.8%; OR, 2.80 [95% CI, 1.59–4.95]; $P = .0002$), a bedfast or chairfast state (mobility ADL score of 5) (64.8% vs 52.2%; OR, 2.15 [95% CI, 1.24–3.74]; $P = .006$), and an inability to transfer (61.9% vs 51.6%; OR, 1.82 [95% CI, 1.07–3.08]; $P = .025$) were significantly associated with clinical cases. ADL data were missing for 21.9% ($n = 23$) of case-patients and 23.4% ($n = 135$) of control subjects.

DISCUSSION

In this analysis of risk factors associated with progression of *C. auris* colonization, we found a significant association between presence of *C. auris* in a clinical specimen and age group, presence of multiple comorbidities, invasive devices, medical procedures, and low patient functional status. Similar to other studies, we found association of invasive devices such as tracheostomy, mechanical ventilation, and feeding tubes with *C. auris* clinical progression [10, 15, 16, 20]. Our analysis also demonstrates a possible association of infection among case-patients with neurologic conditions and recent bronchoscopy procedures, which is consistent with prior studies that suggested certain conditions and invasive procedures increase the likelihood of candidemia [10, 17, 20, 32].

We found case-patients had greater odds of being in the age group 50–64 years. This finding is unexpected and differs from a previous risk factor analysis that demonstrated significant susceptibility to *C. auris* infection in patients aged ≥ 65 years [6]. The ratio observed for 30-day mortality is likely due to a small number of case-patients ($n = 4$) for this variable. The 90-day all-cause mortality findings did not demonstrate a significantly greater odds for clinical cases over colonization. However, we cannot determine a causal relationship between mortality and the presence of *C. auris* due to underlying conditions or other confounding factors. This analysis also provides a unique assessment of the association of ADLs with clinical progression of *C. auris*. Persons fully dependent on care were more likely to experience clinical indications, especially if bedridden and fed by gastrointestinal feeding tube or TPN. Our results reinforce focused screening and clinical assessment and demonstrate the need for robust IPC measures to prevent *C. auris* transmission, particularly focusing on patient functional status (ADL assessment) and healthcare environment [18].

Because Florida continues to be a state with a high prevalence of *C. auris* colonization and clinical cases, this state-level study provides a broader perspective of patients cared for within different facilities (ie, ACHs, long-term care facilities, LTACHs, SNFs, and rehabilitation facilities). These results could be used to improve facility screening protocols, healthcare provider knowledge, and IPC measures to improve patient outcomes within Florida healthcare facilities. Furthermore, case-patients in our analysis were often screened for *C. auris* multiple times despite current recommendations discouraging rescreening after a patient has tested positive for *C. auris* colonization. Rescreening incidence might indicate a need to improve interfacility communication regarding MDRO status during patient transfers.

This analysis has several limitations. Although *C. auris* is nationally notifiable, it is not a reportable condition in the state of Florida other than in healthcare-associated outbreaks. Thus, data used for this analysis were not derived from population-based surveillance, which might limit the generalizability of findings. The first patient with *C. auris* in Florida was identified in 2017, but Florida's electronic reportable disease system was not used for case documentation and reporting purposes until September 2019, resulting in limited case and laboratory data. Lack of a formal FDOH case definition until 2020 also affected identification and documentation of cases. No case-patients or control subjects before 2020 met inclusion criteria for this analysis. A variety of clinical specimens were documented as clinical cases. Though the majority represented candidemia (56.2%), the severity of clinical illness experienced by case-patients was not accounted for in this retrospective analysis. In addition, the associations described are based on unadjusted analysis and the observational study design limits conclusions regarding causality. Healthcare facilities' admission screening protocols for *C. auris* varied and might have resulted in selection bias in certain facilities or geographic areas. Quality and completeness of data submitted to the local and state public health departments varied depending on who was reporting the information on the CRF. Missing medical records and incomplete CRFs affected the number of patients who met the criteria for inclusion in our analysis and resulted in a smaller sample size with lower statistical power to detect associations and might have introduced selection bias. Finally, we did not assess recent medication use for possible contributions to antifungal resistance or clinical progression.

CONCLUSIONS

This analysis is one of the largest of its kind to use data collected from different healthcare facility types in a large US state to assess factors associated with clinical progression among patients colonized with *C. auris*. We found that clinical case-patients were more likely than control subjects to be aged 50–64 years and to have markers of increased morbidity, such as a high number of chronic conditions, invasive devices, medical procedures, and poor functional status. Facilities could consider prioritizing high-acuity patients for early *C. auris* screening, transmission-based precautions, and infection prevention interventions. Identifying risk factors for clinical progression of *C. auris* after colonization could enable facilities to implement more efficient testing protocols and help prevent morbidity associated with invasive infections. Further analysis to understand clinical implications and risk factors for *C. auris* progression after colonization is needed. Future efforts might include an

adjusted analysis to more fully understand the risk that individual medical conditions and functional status have on *C. auris* clinical outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Data availability.

Data are not publicly available.

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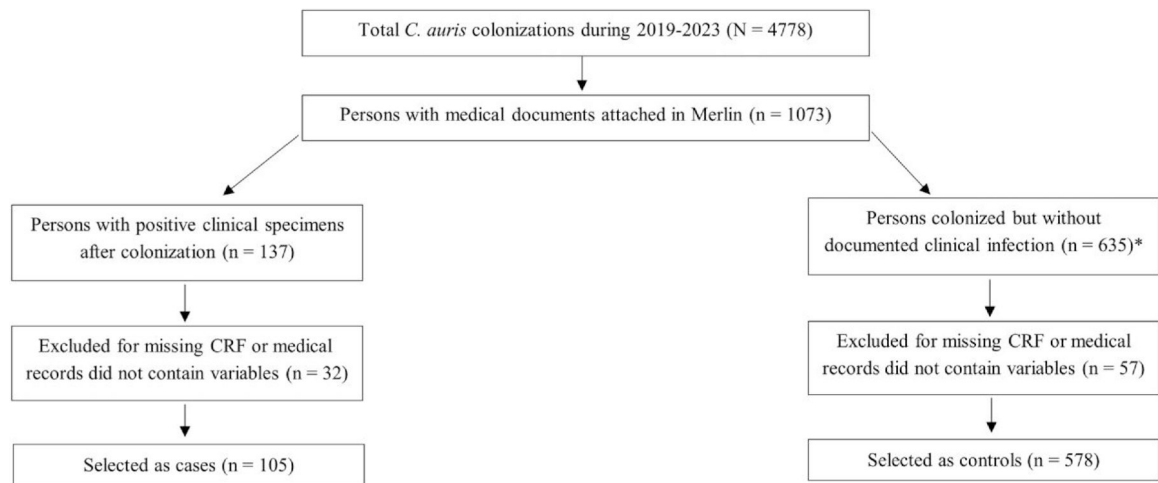


Figure 1.

Flow diagram of inclusion and exclusion criteria to determine case-patients and control subjects in analysis of clinical progression to *Candida auris* infection after colonization.

*Persons with axilla or groin swab positive for *C. auris* in culture but negative by polymerase chain reaction were not included unless a subsequent positive screening laboratory result was present. Abbreviation: CRF, case report form.

Table 1.

Demographic and Laboratory Information for all Florida Residents With Positive *Candida auris* Results in Florida Healthcare Facilities During 2019–2023 Compared With Case-Patients and Control Subjects in Subsample Analysis

Characteristics	All Florida Residents (N = 4778)	Case-Patients (n = 105)	Control Subjects (n = 578)
Sex			
Male	2457 (51.4)	63 (60.0)	317 (54.8)
Female	1765 (36.9)	42 (40.0)	261 (45.2)
Missing ^a	556 (11.6)	0	0
Age, y, median (range)	68 (0–101)	64 (25–93)	69 (19–101)
18–29	89 (1.9)	2 (1.9)	17 (2.9)
30–49	487 (10.2)	13 (12.4)	64 (11.1)
50–64	1272 (26.6)	41 (39.0)	146 (25.3)
65–79	2034 (42.6)	39 (37.1)	246 (42.6)
≥80	880 (18.4)	10 (9.5)	105 (18.2)
Race/ethnicity			
White, non-Hispanic	2069 (43.3)	41 (39.0)	256 (44.3)
Black, non-Hispanic	1304 (27.3)	37 (35.2)	158 (27.3)
Hispanic (all races)	1028 (21.5)	22 (21.0)	118 (20.4)
Asian	47 (1.0)	0 (0)	7 (1.2)
Native Hawaiian or Pacific Islander	3 (0.1)	0 (0)	2 (0.3)
Other	30 (0.6)	5 (4.8)	37 (6.4)
Missing ^a	297 (6.2)	0	0
Positive <i>C. auris</i> specimen source			
Axilla/groin skin swab	3296 (69.0)	105 (100)	578 (100)
Blood	520 (10.9)	59 (56.2)	...
Respiratory	163 (3.4)	12 (11.4)	...
Wound	273 (5.7)	9 (8.6)	...
Urine	431 (9.0)	24 (22.9)	...
Other body fluid	95 (2.0)	1 (1.0)	...
Facility type			
Acute care hospital	3308 (69.2)	52 (49.5)	330 (57.1)
Long-term acute care hospital	1278 (26.8)	51 (48.6)	236 (40.8)

Characteristics	All Florida Residents (N = 4778)	Case-Patients (n = 105)	Control Subjects (n = 578)
Skilled nursing or long-term-care facility	147 (3.1)	2 (1.9)	11 (1.9)
Inpatient rehabilitation facility	10 (0.2)	0 (0)	1 (0.2)
Mortality			
30-d all-cause mortality	...	4 (3.8)	80 (13.8)
90-d all-cause mortality	...	21 (20.0)	113 (19.6)

Data are presented as No. (%) unless otherwise indicated.

^aSex and race/ethnicity data missing in the electronic disease database and unable to be reported for these persons.

Table 2.

Comparison of Characteristics Among Patients With Clinical *Candida auris* Infection After Colonization and Control Subjects With Positive *C. auris* Screening Swabs Without Evidence of Clinical Infection, 2019–2023

Characteristic	Case-Patients (n = 105)	Control Subjects (n = 578)	Odds Ratio (95% CI)	P Value
Age group, y				
18–29	2 (1.9)	17 (2.9)	0.74 (.17–3.34)	.70
30–49	13 (12.4)	64 (11.1)	1.28 (.65–2.54)	.48
50–64	41 (39.0)	146 (25.3)	1.77 (1.09–2.87)	.0195
65–79	39 (37.1)	246 (42.6)	reference	
≥80	10 (9.5)	105 (18.2)	0.60 (.29–1.25)	.17
Medical comorbidities, any	105 (100)	549 (95)	undefined	.019
Chronic lung disease	61 (58.1)	217 (37.5)	2.3 (1.51–3.52)	<.0001
Diabetes mellitus	47 (44.8)	262 (45.3)	0.98 (.64–1.48)	.91
Cardiovascular disease	65 (61.9)	223 (38.6)	2.59 (1.69–3.97)	<.0001
Gastrointestinal disease	37 (35.2)	66 (11.4)	4.22 (2.62–6.79)	<.0001
Malignancy	12 (11.4)	63 (10.9)	1.05 (.55–2.03)	.87
Neurologic condition	55 (52.4)	212 (36.7)	1.90 (1.25–2.89)	.002
Plegias/paralysis	20 (19)	50 (8.7)	2.48 (1.41–4.38)	.0012
Chronic kidney disease	49 (46.7)	169 (29.2)	2.12 (1.39–3.23)	.0004
Skin condition	55 (52.4)	275 (47.6)	1.21 (.80–1.84)	.36
No. of comorbidities				
0–1	6 (5.7)	131 (23.7)	reference	
2–4	60 (57.1)	362 (62.6)	3.62 (1.53–8.57)	.002
≥5	39 (37.1)	85 (14.7)	10.02 (4.07–24.7)	<.0001
Recent invasive devices, any				
Central venous catheter	94 (89.5)	488 (84.4)	1.58 (.81–3.06)	.18
Urinary catheter	52 (49.5)	241 (41.7)	1.37 (.90–2.08)	.14
Surgical drain	44 (41.9)	193 (33.4)	1.44 (.94–2.20)	.09
Endotracheal tube	6 (5.7)	26 (4.5)	1.29 (.52–3.21)	.59
Tracheostomy	7 (6.7)	53 (9.2)	0.71 (.31–1.60)	.405
Mechanical ventilation	59 (56.2)	220 (38.1)	2.09 (1.37–3.18)	.0005
Gastrointestinal feeding tube	44 (41.9)	159 (27.5)	1.90 (1.24–2.92)	.003
	72 (68.6)	306 (52.9)	1.94 (1.25–3.02)	.003

Characteristic	Case-Patients (n = 105)	Control Subjects (n = 578)	Odds Ratio (95% CI)	P Value
No. of invasive devices present				
0–1	25 (23.8)	241 (41.7)	reference	
2–3	40 (38.1)	205 (35.5)	1.88 (1.10–3.21)	.019
≥4	40 (38.1)	132 (22.8)	2.92 (1.70–5.03)	<.0001
Recent medical procedure or service, any	82 (78.1)	423 (73.2)	1.30 (.79–2.13)	.31
Physical therapy	44 (41.9)	206 (35.6)	1.30 (.85–1.99)	.22
Dialysis	24 (22.9)	95 (16.4)	1.51 (.91–2.50)	.11
Wound care	61 (58.1)	279 (48.3)	1.49 (.98–2.26)	.064
Bronchoscopy	9 (8.6)	16 (2.8)	3.29 (1.41–7.66)	.004
No. of medical procedures				
0	23 (21.9)	155 (26.8)	reference	
1–2	57 (54.3)	295 (51.0)	1.30 (.77–2.19)	.32
≥3	20 (19.0)	58 (10.0)	2.32 (1.19–4.55)	.012
Other MDRO infection or colonization in past 90 d	51 (48.6)	168 (29.1)	2.09 (1.32–3.31)	.001
Shared room during admission	13 (12.4)	87 (15.1)	0.73 (.39–1.37)	.33
>1 healthcare facility admission in past 12 mo	77 (73.3)	394 (68.2)	1.28 (.81–2.05)	.29
ADL assessment (ADL = 5)				
Eating, tube-fed or TPN	79 (75.2)	317 (54.8)	2.80 (1.59–4.95)	.0002
Mobility, wheeled, or bedfast	68 (64.8)	302 (52.2)	2.15 (1.24–3.74)	.006
Transfer, cannot get out of bed	65 (61.9)	298 (51.6)	1.82 (1.07–3.08)	.025
Toileting, incontinent	66 (62.9)	340 (58.8)	1.34 (.80–2.25)	.27
Missing ADL data	23 (21.9)	135 (23.4)	...	...

Data are presented as No. (%) unless otherwise indicated.

Abbreviations: ADL, activities of daily living; CI, confidence interval; MDRO, multidrug-resistant organism; TPN, total parenteral nutrition.