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MAJOR ARTICLE

Impact of the COVID-19 Pandemic on *Candida auris* Infections: A Retrospective Analysis in an Academic Medical Center in New York City

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Background. *Candida auris* (*C. auris*), a multidrug-resistant fungus first described in Japan in 2009, has since spread rapidly around the world. More recently, cases of *C. auris* have increased substantially, which may have been affected by the strain the coronavirus disease 2019 (COVID-19) pandemic placed on health care resources. We describe the epidemiology of *C. auris* infection and colonization at a tertiary care hospital in New York City before, during, and after the peak of the COVID-19 pandemic and describe our approach to surveillance.

Methods. We performed a retrospective chart review for all incident cases of *C. auris*, defined as a patient without a known history of infection or colonization who had a positive surveillance or clinical culture detected at our institution from 2019 through 2022. Clinical and demographic data were collected using the electronic medical record.

Results. Sixty-four incident cases of *C. auris* were identified. Thirty-four of these were identified by surveillance and 30 by clinical culture. There was a statistically significant increase in the number of cases identified in 2022 compared with 2019, with incidence rates of 2.6 cases per 10 000 admissions in 2019 and 7.8 cases per 10 000 admissions in 2022 ($p = .002$), respectively.

Conclusions. The incidence of *C. auris* colonization or infection increased significantly at our institution during the COVID-19 pandemic, reflecting the potential impact the pandemic had on *C. auris* transmission. Targeted admission surveillance allows for the early identification of *C. auris* cases and can serve as a valuable tool to combat the increasing transmission of *C. auris*.

Keywords. admission surveillance; *Candida auris*; COVID-19; infection control; multidrug-resistant organism.

Candida auris is a multidrug-resistant fungus that has rapidly spread around the world since it was first described in Japan in 2009 [1]. First detected in the United States in 2016, initial cases were linked to international importation [1]. As a result of its ability to colonize patients for prolonged periods of time and to persist in the health care environment, cases in the United States now predominantly reflect local transmission [2]. Some areas of the United States, such as New York City, are currently experiencing extensive spread of *C. auris* within and across health care facilities [2].

The spread of *C. auris* in the United States was initially gradual, but more recently cases have increased at an alarming rate. Between 2019 and 2021, clinical cases of *C. auris* increased by >200%, and the number of positive screening cultures increased by 275% [2]. Several factors contributed to this, including the US Center for Disease Control and Prevention's (CDC) institution of a national notification mandate for all clinical cases of *C. auris* in 2019 and the expansion of screening practices across the country. In addition, it has been hypothesized that the emergence of coronavirus disease 2019 (COVID-19) was a significant factor, as surges in COVID-19 correlated with the spread of other multidrug-resistant organisms (MDROs) [3, 4].

Before the COVID-19 pandemic, *C. auris* was designated by the CDC as 1 of 5 organisms considered to be an "urgent threat" to public health due to its resistance to most available antifungals, its propensity to spread easily between patients in hospitals and nursing homes, and its ability to cause severe infections in hospitalized patients [5]. The COVID-19 pandemic stressed all aspects of health care infrastructure, causing unprecedented scarcities of critical supplies, draining financial resources, and creating health care personnel staffing shortages. These stressors necessitated the development of strategies to preserve personal protective equipment (PPE) stockpiles and adaptations to clinical workflows to reduce staff burdens. These practices, such as extended use of PPE and the use of new or additional PPE, led to lapses in adherence to infection prevention protocols, including those designed to prevent the

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transmission of MDROs, such as *C. auris,* among hospitalized patients [6–9]. Additionally, the indiscriminate use of broad-spectrum antimicrobials to empirically treat superimposed bacterial infections in patients with COVID-19 may have also favored the selection of MDROs. Given the threat *C. auris* poses and its recent exponential growth, it is crucial to understand the changes in the epidemiology of *C. auris* that occurred during and after the COVID-19 pandemic. We describe the incidence, demographics, comorbidities, and risk factors for *C. auris* infection or colonization among adult inpatients at an academic tertiary care hospital in New York City, a "hot spot" of *C. auris* spread, from 2019 through 2022, and explore the effects of the COVID-19 pandemic. We also describe our approach to *C. auris* surveillance and how it has changed over this time period.

METHODS

Surveillance Plan

The Mount Sinai Hospital is a 1018-bed academic, tertiary care referral hospital located in New York City. Throughout the study period, criteria for surveillance testing were applied to all adult acute care inpatients, with the exclusion of those on behavioral health or labor and delivery units. In consultation with the New York State Health Department (NYSDOH), in June 2017 we initiated targeted surveillance of patients admitted from nursing homes (NH) and skilled nursing facilities (SNFs) in the region that were known to be experiencing outbreaks of *C. auris* (Figure 1). During the subsequent two years, we increased the number of target facilities. In January of 2019, due to an increase in cases identified in Brooklyn, New York, we expanded our targeted admission surveillance to include all patients admitted from an SNF, NH, or hospital in Brooklyn. In October of 2021, due to the high burden of *C. auris* in our immediate region, we expanded our admission surveillance to include all patients admitted from an NH, SNF, or hospital in New York or New Jersey, and in October of 2022 this was expanded further to include all patients admitted from any NH or SNF. In December of 2022, we added all patients colonized or infected with a newly identified carbapenem-resistant Enterobacterales (CRE) to our surveillance plan, and most recently, in April of 2023, we added all patients transferred from any hospital outside of our health system. Additionally, since 2021, per CDC and NYSDOH guidance, we have performed targeted surveillance of patients who report international hospitalization within the previous year and those with a known *C. auris* exposure [10]. Patients who meet criteria for surveillance are identified by clinical surveillance software (VigiLanz, Minneapolis, MN, USA). The clinical surveillance software scans Emergency Department notes for keywords such as "NH," "SNF," and "nursing home" to select patients for manual review. Additionally, addresses containing locations and/or names of NH or SNF recognized to have patients with *C. auris* are flagged by the software. In addition to alerts from the clinical surveillance software, the Infection Prevention Department receives notification from the Emergency Department and Bed Management regarding transfers from a NH, SNF, or outside hospital for review. Surveillance cultures are ordered by the Infection Prevention Department for patients who meet surveillance criteria based on these notification streams.

Microbiology

Surveillance specimens include one sample of bilateral nares and one combined sample for the axilla and groin and are performed by the patient's nurse. Specimens are cultured in selective medium designed for the isolation and identification of yeast and filamentous fungi, as well as the differentiation of *Candida albicans*, *Candida tropicalis*, and *Candida krusei,* using BBL CHROMagar *Candida*. Cream to pale pink–colored colonies suggestive of *C. auris* are then isolated on Sabouraud Dextrose (Sab-Dex) agar and subsequently identified using matrix-assisted laser desorption/ionization time of flight mass spectrometry (MALDI-TOF MS; Bruker) [11].

Data Collection and Analysis

We performed a retrospective chart review for all incident cases of *C. auris*, defined as a patient without a known history of *C. auris* infection or colonization who had a positive surveillance or clinical culture detected at our institution from 2019 through 2022. Clinical and demographic data were collected using the medical record. The data included patient age, gender, location from which the patient was admitted, length of stay from admission to positive culture, and death during index hospital stay. Abstracted comorbidities and risk factors included diabetes mellitus, chronic lung disease, chronic kidney disease, hemodialysis, liver disease, cerebral vascular accident, malignancy (solid or hematologic), history of organ transplant, presence of mechanical ventilation or an indwelling catheter/device at the time of culture collection, intensive care unit stay, administration of antimicrobials before the index culture during the admission within which the patient tested positive for *C. auris*, hospitalization in the prior 6 months, a stay in an SNF or NH in the prior 6 months, and history of prior colonization with an MDRO. MDROs were limited to CRE, MDR *Acinetobacter* species, MDR *Pseudomonas aeruginosa*, methicillin-resistant *Staphylococcus aureus*, and vancomycin-resistant *Enterococcus*. Indwelling catheters/devices included central venous catheters, percutaneous endoscopic gastrostomy tubes, indwelling urinary catheters, and tracheostomies. Additionally, data related to the index culture, including type of culture (ie, surveillance or clinical), source of culture (eg, blood, sputum, nares, axilla/groin), and indication for surveillance culture (eg, hospital transfer, SNF, NH) was collected. Proportions of these data points from 2019 were compared with 2022 to evaluate if there were any differences in our populations before and after the height of the COVID-19 pandemic, using an

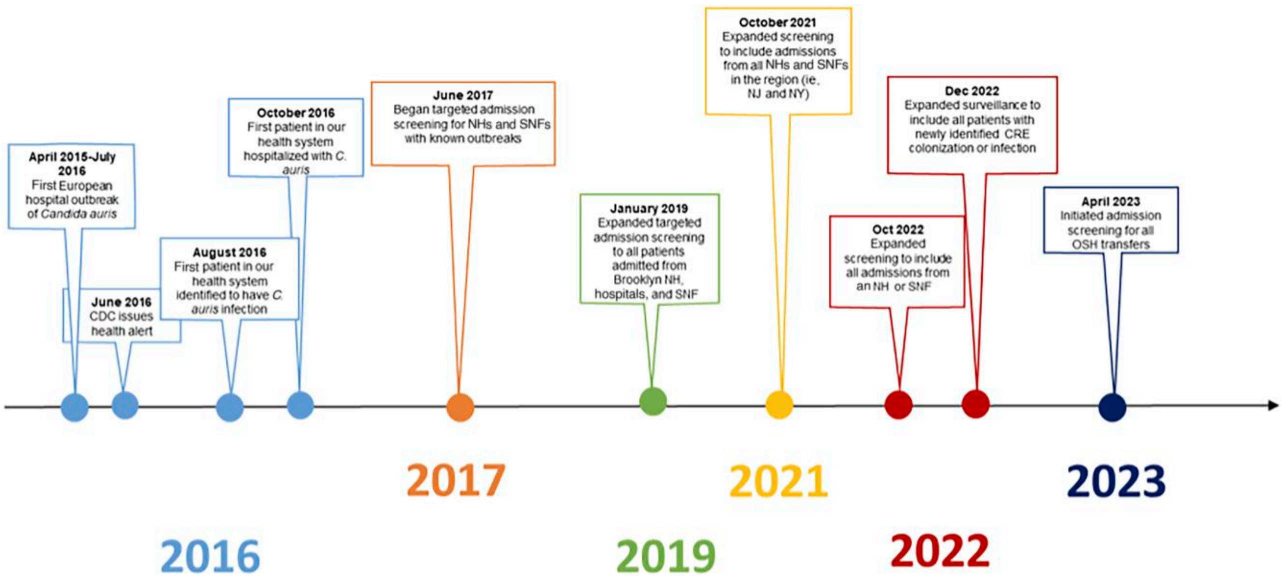

Figure 1. The evolution of targeted surveillance for *Candida auris* at a New York City academic medical center. Abbreviations: CDC, Centers for Disease Control and Prevention; CRE, carbapenem-resistant Enterobacterales; NH, nursing home; OSH, outside hospital; SNF, skilled nursing facility.

online Fisher exact calculator [12]. Risk factors and comorbidities for patients in the 2020 and 2021 groups were not included in the analysis as these years were considered "midpandemic" years.

As there is no standardized definition for hospital-onset *C. auris,* we applied the CDC definition of hospital-onset that is used for other MDROs, which is a hospital length of stay of four or more days at the time of culture collection.

Percent positivity for colonization with *C. auris* is calculated using positive surveillance cases and the number of patients who were tested. Clinical incidence was calculated using the number of positive clinical cultures and the number of adult admissions per year, excluding behavioral health and labor and delivery.

To reflect the overall burden of *C. auris* at the institution, we calculated a combined incidence of positive clinical and surveillance cultures using the number of admissions per year, excluding admissions to behavioral health and labor and delivery units. To evaluate the potential impact of COVID-19 on the overall incidence of *C. auris,* we compared incidence rate ratios from 2019 and 2022. Rate ratios were calculated using Medcalc Software (Belgium) [13].

RESULTS

Surveillance Positivity and Clinical Incidence

Sixty-four incident cases of *C. auris* were identified from 2019 through 2022. Thirty-four of these cases were identified by surveillance culture, and 30 were identified by clinical culture. Surveillance positivity rates are described in Table 1. The number of individuals screened for *C. auris* increased from 587 in 2019 to 1134 in 2022 due to changes in the facility-wide *C. auris* surveillance plan. Surveillance positivity by year ranged from a low of 0.5% in 2019 to a high of 1.5% in 2020 (Table 1). Comparing incident cases from 2019 with those identified in 2022, there was not a significant change in the percent positive among surveillance cultures ($p = .08$) [14]. Of the 34 patients identified to be colonized with *C. auris* based on surveillance cultures, 3 (8.8%) went on to develop a clinical infection with *C. auris* after their initial surveillance, all occurring in 2022.

Table 1. *Candida auris* Surveillance Culture Positivity by Year

Year	Patients With Positive Surveillance, No.	Patients Surveilled, No.	Positive, %
2019	3	587	0.5
2020	8	536	1.5
2021	7	772	0.9
2022	16	1134	1.4
Total	34	3029	1.1

Among cases identified by active surveillance, in 2019, 2 (67%) were identified due to admission from an SNF or NH and 1 (33%) on transfer from a target hospital. In 2020, 6 (75%) were identified on admission from an SNF or NH and 2 (25%) on transfer from a target hospital. In 2021, 5 (71%) were identified on admission from an SNF or NH and 2 (29%) on transfer from a target hospital, and in 2022, 11 (69%) were identified on admission from an SNF or NH, 2 (12%) from target hospital, and 3 (19%) as part of a contact investigation.

Clinical incidence by year is described in Table 2. From 2019 through 2022, there were 130 403 admissions to our institution.

Table 2. Clinical Incidence of *Candida auris* by Year

Year	Patients With Positive Clinical Culture, No.	Medical–Surgical Admissions	Incidence per 10 000 Admissions	Clinical Cases Considered Hospital-Onset, No. (%)
2019	6	34 438	1.7	5 (83.3)
2020	5	24 819	2.0	4 (80.0)
2021	7	35 021	2.0	4 (57.1)
2022	12	36 125	3.3	10 (83.3)
Total	30	130 403	2.3	23 (76.7)

There were 30 clinical cases for *C. auris* in this time period, with an overall incidence of 2.3 cases per 10 000 admissions. Clinical incidence per 10 000 admissions increased from 1.74 in 2019 to 3.32 in 2022, though this was not statistically significant ($p = .19$). Of the 30 incident clinical cases identified from 2019 through 2022, 23 (76.7%) were considered hospital-onset (HO). The proportion of hospital-onset cases remained relatively stable from 2019 through 2022, with 2021 having the smallest proportion of hospital-onset cases at 4 (57.1%), while 2019, 2020, and 2022 each had ~80% of incident cases defined as hospital-onset.

Total incidence, including incident clinical and surveillance cases from 2019 through 2022, was 4.9 cases per 10 000 admissions. Comparing the overall incidence rate from 2019 with that of 2022, there was a statistically significant increase, with incidence rates of 2.6 cases per 10 000 admissions in 2019 and 7.8 cases per 10 000 admissions in 2022 ($p = .002$), respectively, reflecting an increase in the overall burden of known *C. auris* cases at the institution.

Demographics, Comorbidities, Risk Factors, and Characteristics of Cultures

Of the 37 individuals in our comparison groups, the ages ranged from 55 to 92 for 2019 (n = 9) and from 19 to 83 for 2022 (n = 28), with both groups having a mean age of 62 years. Gender, comorbid conditions, and risk factors are presented in Table 3. Hospital duration before incident surveillance culture ranged from 1 to 2 days in 2019 and from 2 to 84 days (median, 5 days) in 2022. Hospital duration before incident clinical culture ranged from 1 to 19 days in 2019 (median, 8 days) and from 2 to 101 days (median, 25 days) in 2022. In 2019, 3 patients (33%) were admitted from home, 4 (44%) from an SNF or NH, and 2 (22%) were transferred from another hospital. In 2022, 9 patients (32%) were admitted from home, 16 (57%) from an SNF or NH, and 3 (11%) from another hospital. The number of incident positive patients who spent time in an SNF or NH in the 6 months before their positive culture increased from 4 (44%) in 2019 to 16 (57%) in 2022, and those who were hospitalized in the 6 months before their positive culture increased from 5 (55%) in 2019 to 20 (71%) in 2022, though neither was statistically significant.

Table 3. Demographics and Clinical Characteristics of Patients Colonized or Infected With *Candida auris* in 2019 (n = 9) and 2022 (n = 28)

	2019, No. (%)	2022, No. (%)	*p* Value
Gender (male)	6 (66.7)	16 (57.1)	.71
Admitted to SNF or NH in past 6 mo	4 (44.4)	16 (57.1)	.70
Hospitalization in past 6 mo	5 (55.6)	20 (71.4)	.43
On hemodialysis at time of culture	2 (22.2)	6 (21.4)	1
Device present at time of culture	6 (66.7)	23 (82.1)	.37
Diabetes	4 (44.4)	18 (64.3)	.44
Chronic lung disease	3 (33.3)	1 (3.6)	.04*
Chronic kidney disease	2 (22.2)	7 (25.0)	1.0
Liver disease	1 (11.1)	4 (14.3)	1.0
Stroke/CVA	0 (0)	4 (14.3)	.50
Malignancy	2 (22.2)	8 (28.5)	1.00
Organ transplant	2 (22.2)	2 (7.1)	.24
Colonized with other MDRO	1 (11.1)	15 (53.6)	.05
Receipt of antifungals before culture	3 (33.3)	5 (17.9)	.37
Receipt of antibiotics before culture	9 (100)	24 (85.7)	.55

Abbreviations: CVA, cerebral vascular accident; MDRO, multidrug-resistant organism; NH, nursing home; SNF, skilled nursing facility.
**p* value < 0.05 determined to be statistically significant.

Proportions of comorbid conditions were compared between 2019 and 2022. A significant increase in patients colonized with an MDRO was noted, from 11% in 2019 to 54% in 2022 ($p = .05$). Chronic lung disease decreased significantly from 2019 to 2022 ($p = .04$). All other comorbid conditions did not change significantly among incident positive patients when compared between 2019 and 2022. Notably, a high proportion of patients in both time periods had an indwelling device at the time of positive culture, 82.1% of patients had 1 or more indwelling devices in 2022, and 66.7% of patients had 1 in 2019.

Of the 30 incident cases identified by clinical culture, 19 had surveillance cultures sent after the incident clinical culture. Eleven of those 19 (57.9%) patients had *C. auris* detected by surveillance. Adding these patients to our patients with incident positive surveillance cultures, we had a total of 45 patients with positive surveillance cultures. Twenty-six (58%) of these patients were identified through nares samples alone, 5 tested positive on both nares and axilla/groin samples, and 14 individuals tested positive by axilla/groin sample alone. One individual who tested positive by nares also had a positive surveillance specimen of unknown source.

DISCUSSION

Progress in the fight to control MDROs including *C. auris* regressed during the COVID-19 pandemic. This was evidenced by the increased reports of MDRO outbreaks globally and a reported 15% increase in deaths caused by MDRO infections since the onset of the pandemic [15]. A 2022 report issued by the CDC described a 35% increase in hospital-onset CRE infections, a 78% increase in hospital-onset carbapenem-resistant *Acinetobacter* cases, and a 60% increase in clinical cases of *C. auris* [15].

The increase in MDROs has likely been accelerated by multiple factors associated with the pandemic, such as staffing and supply shortages, overuse or misuse of PPE, lapses or variations in infection control practices, and general stressing of health care systems globally. Strategies to prevent staff from becoming ill and to preserve PPE may have inadvertently increased the transmission of MDROs from environment to patient or patient to patient [3]. In one institution, an outbreak of invasive *C. auris* was potentially linked to extended-use gowns and gloves, as well as breaks in hand hygiene, cleaning, and disinfection [16]. The pandemic also shifted the acuity of patients in many institutions. Ventilator use, a known risk factor for *C. auris*, increased during the pandemic, and mechanical ventilation was identified as a driver of a *C. auris* outbreak in an Israeli hospital [17]. The need for more equipment also increased the opportunity for transmission through shared equipment and supplies. Staffing shortages decreased the amount of time staff had to properly clean and disinfect equipment and perform hand hygiene and at the same time increased the number of patients health care workers were caring for at any given time [4]. Similarly, the increase of MDRO coinfection or co-colonization between 2019 and 2022 in our study population likely reflects the general increase of MDROs in health care settings postpandemic [15]. While this may not be unique to those colonized or infected with *C. auris*, the high rate of co-colonization reinforces the addition to our surveillance plan made in December of 2022 to include patients colonized with CRE.

The increase in the overall burden of *C. auris* seen at our facility between 2019 and 2022 mirrors the increase in incidence across the United States and globally [2]. The evolving breadth of our surveillance plan makes it difficult to ascertain whether our findings reflect an increase of *C. auris* in nonhospital health care settings such as NHs and SNFs, an artifact of a surveillance plan that has become more comprehensive over time, or both. While we did not note a statistically significant increase in the incidence rate based on surveillance cultures alone from 2019 to 2022, during that time our surveillance plan expanded considerably. That led to a 2-fold increase in the number of patients screened and a 5-fold increase in the number of positive patients identified, which suggests that the reach of the surveillance plan continues to target appropriate populations at high risk for *C. auris* colonization. Our surveillance plan targets SNF and NH admissions, and we noted a substantial increase in the proportion of patients detected on admission from an SNF or NH from 2019 to 2022, suggesting that *C. auris* has become endemic in the SNF and NH population in our region.

A targeted pilot screening program conducted in high-risk units in selected New York City facilities from 2017 to 2019 had a positivity rate of 6.9% [18]. Although our surveillance plan is also aimed at high-risk individuals, it does not account for clinical risk factors for *C. auris* such as ventilator use or antimicrobial exposure, making our 1.1% surveillance positivity rate reflective of a more general population than that of the NYC pilot study [19]. Additionally, though the increase noted in our clinical incidence rate alone was not statistically significant, like our surveillance data, the absolute number of clinical cases did increase from 6 in 2019 to 12 in 2022, resulting in an almost doubling of the clinical incidence rate (from 1.7 to 3.3).

The ability of *C. auris* to survive in the environment facilitates its persistence and transmission in health care settings. This has been documented numerous times, most notably by Oxford University Hospital in their report of an 18-month outbreak linked to reusable patient equipment. In that instance, even after recommended *C. auris* outbreak infection control measures were implemented, including patient isolation, enhanced cleaning with chlorine-based products, reduced bedside equipment, and decluttering, *C. auris* was not completely eliminated and cases continued to be diagnosed [20]. Proactive implementation of infection control measures, such as targeted surveillance, are most effective because they allow for early identification and subsequent isolation of patients colonized with *C. auris* [21, 22]. The effectiveness of early detection and implementation of infection control measures was demonstrated in Orange County, California, during their response to initial cases in 2019 [23]. In their report, it was shown that the identification of colonization before a clinical infection reduced the risk of exposure to other patients, the chance for nosocomial transmission, and the burden placed on hospital resources, including infection prevention staff, environmental services, and nursing leadership, in the setting of a hospital-onset case or outbreak.

Expanding our facility surveillance plan resulted in the early detection of 3 individuals during surveillance who went on to develop clinical infection in 2022. This group of individuals would otherwise not have been identified until their clinical infection occurred. The number of days that elapsed between each patient's positive surveillance culture and positive clinical culture was 11, 24, and 63 days. These patients were promptly placed on transmission-based precautions after their surveillance culture resulted, which in total avoided 14 weeks of potential exposure of *C. auris* to other patients, contact tracing in the inpatient setting, and environmental contamination. Conducting active surveillance on upwards of 1000 patients per year can be costly in labor and hospital resources. However, a look at a large *C. auris* outbreak in London estimated that the response to the outbreak cost upwards of $70 000 per month [24]. Applying this estimate, our surveillance plan potentially saved $228 000 in outbreak response with these 3 patients alone and, importantly, prevented the potential silent transmission that could have occurred in the other surveillance positive patients had they gone undetected. Through our active surveillance plan, 1 out of every 91 patients screened positive, and given the impact just 1 patient can have on the health care environment, this early detection by active surveillance likely improved patient outcomes by preventing transmission and sparing hospital resources. Furthermore, we identified and isolated 31 patients through our active surveillance program who never went on to develop a clinical infection. These patients would have served as a silent reservoir of *C. auris* for the duration of their hospital stay, potentially transmitting to other patients and the environment.

The CDC identifies the skin of the axilla and groin as the preferred site for collection of *C. auris* surveillance cultures, though *C. auris* has been found in other body sites such as the nares [25, 26]. A study conducted in New York State found that 80% of axilla/groin samples tested positive, while only 58% of nares samples tested positive. In this study, 100% of nares/axilla/groin composite swabs were positive. Additionally, it was found that the nares contained more *C. auris* [23]. In our study population, over half of the 45 positive surveillance specimens were detected on the nares culture and negative on composite specimens of the axilla and groin. Due to the positive yield of the nares specimens at our institution and evidence that nares may contain a higher burden of organisms, we continue to sample all 3 sites.

The region served by our hospital has a relatively high density of *C. auris*, so the results and utility of active surveillance discussed in this article may not be generalizable to other locations. We had a relatively small sample size of 64 cases overall, with only 37 cases from 2019 and 2022, limiting the feasibility and power of statistical analyses. Furthermore, our study population includes a mixed population of surveillance and clinical cases, for which clinical and epidemiological risk factors may not be the same. Analyzing these groups as one may have impacted our ability to identify changes in clinical comorbidities and risk factors over time. However, inclusion of all positive patients, regardless of whether identified by surveillance or clinical culture, was important to demonstrate the overall increase in the burden of *C. auris* at our institution. Additionally, because our study does not include a control group, we cannot assess if differences in comorbidities and risk factors found before and after COVID-19 are specific to our study population. Further case–control studies would be a beneficial addition to the literature to increase our understanding of the ways that COVID-19 affected the transmission and risk factors for *C. auris*.

The incidence of *C. auris* colonization or infection increased significantly at our institution during the COVID-19 pandemic. Our results highlight the potential impact the COVID-19 pandemic had on the spread of MDROs and the potential for targeted admission surveillance to serve as a valuable tool to combat the increasing spread of *C. auris*. We also demonstrated the importance of continually re-evaluating a surveillance plan to allow for changes as new information is gathered regarding transmission and predictors of infection or colonization.

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Patient consent. This de-identified retrospective study was approved by the Icahn School of Medicine at Mount Sinai Institutional Review Board and determined to not necessitate patient consent.

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