

COMPARATIVE MICROBIAL ASSESSMENT OF HEALTH FACILITY AND NON-HEALTH FACILITY AIR-CONDITIONING UNITS IN CALABAR, NIGERIA

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ABSTRACT

Air-conditioning units in tropical regions create indoor environments which serve as breeding grounds for microbial pathogens that increase chances of disease spread in healthcare settings. This study compared microbial contamination in AC units from health and non-health facilities in Calabar, Nigeria. A cross-sectional study design was adopted and a sample size of 115 AC units (67 health, 48 non-health) was used. Swabs from filters, coils, and pans were cultured on selective media. Isolates were identified biochemically and morphologically. Data were analyzed using chi-square tests ($P < 0.05$). Result shows that contamination affected 40% (46/115) of units, with 41.8% in health vs. 37.5% in non-health facilities ($P = 0.60$). Bacteria predominated (39 isolates) were *Staphylococcus aureus* (43.6%), *Pseudomonas aeruginosa*, *Klebsiella* spp. (23.1% each), *Legionella* spp. (7.7%) and *Bacillus* spp. (2.6%). While the fungi (7 isolates) included, *Aspergillus flavus* (57.1%) and *Penicillium* spp. (42.9%). Co-contamination occurred in 5.2%. Health facilities showed higher bacterial loads, but differences were non-significant ($P > 0.05$). The study concludes that AC units in Calabar harbor pathogenic microbes, with health facilities at marginally higher risk. Thus, routine maintenance is crucial to prevent bioaerosol-related infections in tropical settings.

Keywords: Air-conditioning; Microbial contamination; bacteria; fungi; Nigeria

INTRODUCTION

In tropical regions like Nigeria, air-conditioning (AC) systems are essential for indoor comfort but can accumulate moisture and dust, fostering microbial biofilms (Uzuegbunam et al., 2018). These pollutants, notably bacteria and fungi may become aerosolized and spread throughout the indoor environment through circulating air currents (Hussain et al., 2022). Continuous exposure to contaminated air can raise the risk of respiratory tract infections, allergic responses, asthma exacerbations, and other health issues, especially among immunocompromised individuals, patients, healthcare professionals, and inhabitants of poorly ventilated facilities.

In healthcare settings, the presence of harmful microorganisms in AC units may further contribute to the spread of healthcare-associated diseases and degrade indoor air quality (Hussain et al., 2022; Gorlach et al., 2025). Health facilities, with high patient turnover, are particularly vulnerable to nosocomial pathogens, while non-health settings (e.g., offices) face environmental exposures (Gorlach et al., 2025). Common isolates include *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Aspergillus* spp., linked to pneumonia and aspergillosis (Wijedoru et al., 2017). In humid Calabar, perennial

moisture exacerbates contamination (Olukosi et al., 2018). Nigerian studies report high bacterial loads in ACs, with *Bacillus* and *Aspergillus* prevalent. Comparative data are limited, yet vital for infection control amid rising HAIs (Otu-Bassey et al., 2021). This study compares microbial profiles in health vs. non-health AC units, hypothesizing higher pathogenic diversity in health settings due to bioaerosol exposure. Findings inform tropical biomedicine strategies for safer indoor air.

METHODOLOGY

Study design and population: Cross-sectional survey in Calabar, Nigeria (April–August 2023). Sampled 115 AC units: 67 from health facilities (hospitals/clinics), 48 from non-health facilities (offices/hotels). Oral consent and approval were sought and obtained from facility managers.

Sampling and culture: Sterile swab samples were collected from the filters, coils, and drain pans of the air-conditioning units and subsequently transported in peptone water for microbiological analysis. Inoculated on nutrient/MacConkey agar (bacteria, 37°C/24-48h) and Sabouraud agar (fungi, 25°C/3-7d).

Identification:

Bacteria: Gram stain, biochemical tests (catalase, coagulase, etc.).

Fungi: Lactophenol blue microscopy.

Statistical analysis: Frequencies, percentages; chi-square for comparisons (SPSS v25, $p < 0.05$).

RESULTS AND DISCUSSION

Microbial contamination was detected in 46/115 (40.0%) units. Health facilities had 28/67 (41.8%) contaminated vs. 18/48 (37.5%) in non-health ($\chi^2 = 0.28$, $p = 0.60$). Bacteria dominated (39 units), fungi in 7, co-contamination in 6 (Table 1).

Table 1: Distribution and contamination status of air-conditioning units by facility type

Facility Type	Total Units	Contaminated n (%)	Bacteria n (%)	Fungi n (%)	Co-contamination n (%)
Health	67	28 (41.8)	24 (35.8)	4 (6.0)	4 (6.0)
Non-Health	48	18 (37.5)	15 (31.3)	3 (6.3)	2 (4.2)
Total	115	46 (40.0)	39 (33.9)	7 (6.1)	6 (5.2)

Table 1 illustrates overall contamination, with health facilities showing marginally higher rates, though non-significant ($p = 0.60$). Bacterial dominance suggests moisture-driven growth.

Table 2: Distribution of bacterial isolates by facility type

Species	Health n (%)	Non-Health n (%)	Total n (%)
<i>S. aureus</i>	11 (44.0)	6 (42.9)	17 (43.6)
<i>P. aeruginosa</i>	6 (24.0)	3 (21.4)	9 (23.1)
<i>Legionella</i> spp.	2 (8.0)	1 (7.1)	3 (7.7)
<i>Bacillus</i> spp.	1 (4.0)	0 (0.0)	1 (2.6)
<i>Klebsiella</i> spp.	5 (20.0)	4 (28.6)	9 (23.1)
Total	25 (100)	14 (100)	39 (100)

Bacterial distribution was similar ($\chi^2 = 1.42$, $p = 0.84$), with *S. aureus* prevalent, indicating human-derived contamination.

Table 3: Distribution of fungal isolates by facility type

Species	Health n (%)	Non-Health n (%)	Total n (%)
<i>Penicillium</i> spp.	2 (50.0)	1 (33.3)	3 (42.9)
<i>A. flavus</i>	2 (50.0)	2 (66.7)	4 (57.1)
Total	4 (100)	3 (100)	7 (100)

Fungal patterns were comparable ($\chi^2 = 0.29$, $p = 0.59$), with *A. flavus* dominant, a tropical allergen.

Table 4: Comparative prevalence of contamination types

Type	Health n (%)	Non-Health n (%)	χ^2 (p)
Bacterial Only	20 (71.4)	13 (72.2)	0.004 (0.95)
Fungal Only	0 (0.0)	1 (5.6)	1.62 (0.20)
Co-contamination	4 (14.3)	2 (11.1)	0.09 (0.76)
Uncontaminated	39 (58.2)	30 (62.5)	0.28 (0.60)
Total Contaminated	28 (41.8)	18 (37.5)	-

Contamination types showed no differences, emphasizing bacterial focus for interventions.

Contamination rates (40%) align with tropical studies (Upula et al., 2023). Non-significant differences suggest universal risks, but health facilities' higher bacterial loads imply patient-derived sources. Pathogens like *S. aureus*

and *P. aeruginosa* pose HAI threats (Upula et al., 2023; Out-Bassey et al., 2021). Fungi, though low, warrant attention in immunocompromised settings (Kohler et al., 2017). Limitations: culture-based methods may

underestimate; future PCR needed. Tropical humidity exacerbates issues; regular disinfection recommended. Comparatively, within Africa, this finding of 40% overall contamination and bacterial dominance are lower than some regional reports. For instance, a previous study in Calabar, Nigeria, found 100% bacterial contamination in AC filters from hotels, offices, and hospitals, with *Bacillus* spp. (50.8%) and *Aspergillus niger* (60%) prevalent, highlighting potentially higher risks in diverse settings (Otu-Bassey et al., 2021). In Ethiopia's Jimma Medical Center, indoor air microbial loads reached 466 CFU/m³ in wards, dominated by *Staphylococcus* and *Bacillus*, exceeding this qualitative assessment and underscoring hospital-specific burdens (Belay et al., 2024). Harar private clinics in Ethiopia reported fungal loads of 351-401 CFU/m³, higher than this low fungal prevalence (6.1%), possibly due to differences in sampling methods or ventilation (Temesgen et al., 2024). South African hospital studies identified the genera *Bacillus*, *Kocuria*, and *Staphylococcus* with counts up to 6×10⁴ CFU/m³ in kitchens and wards, aligning with this bacterial focus but indicating seasonal or occupancy influences (Setlhare et al., 2024). Across Africa, including Benin City, Nigeria, and Morocco's Agadir hospital (fungal counts 29-176 CFU/m³), contamination often exceeds acceptable limits in healthcare, driven by poor maintenance and high humidity. This study's lower rates may reflect improved awareness, but emphasize the need for standardized protocols continent-wide (Oulkheir et al., 2021; Ogefere et al., 2025). Globally, these results mirror patterns in Asia and beyond, where HVAC systems harbor antibiotic-resistant bacteria, with reviews stressing maintenance to curb risks. In Chengdu, China, household bacterial counts reached 12,296 CFU/cm² in water sinks, dominated by *Methylobacterium* and *Bacillus*, far higher than this prevalence, likely due to sampling intensity (Sun et al., 2024). Japanese studies on 17 houses revealed *Pseudomonas* and *Staphylococcus* as top genera on filters, similar to our *S. aureus* dominance, with Gram-negative bacteria prevalent (Watanabe et al., 2022). A scoping review indicated lower microbial loads in well-managed AC areas globally, but increased infections if neglected, as in this non-significant health vs. non-health differences (Wu et al., 2021). Comprehensive reviews highlight sources like coils and filters fostering biofilms, with global risks amplified in humid tropics. Compared to temperate regions (e.g., Europe, USA), where seasonal variations reduce year-round growth, tropical Africa faces perennial

challenges, necessitating adapted strategies like HEPA filters seen in Italian hospitals (70-90% reduction) (Bakker et al., 2020; Kravchenko et al., 2023).

CONCLUSION

This study concludes that AC units in Calabar harbor microbes, with health facilities at elevated risk. Enhanced maintenance is vital for tropical infection control.

RECOMMENDATION

Healthcare facilities should establish regular cleaning and disinfection procedures for all AC system components which include filters and coils and ducts to decrease microbial buildup and biofilm development. Additionally, healthcare facilities should include AC maintenance activities into their current IPC programs while focusing on important locations which include wards and intensive care units and operating theatres.

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