RESEARCH ARTICLE

# Monitoring aeromicroflora to prevent nosocomial infections in critical hospital wards using Spin Air v2 technology

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**Objective**: The wider introduction of air quality monitoring in Romanian hospitals is essential for compliance with international standards of air quality. Effective monitoring enables rapid and targeted preventive interventions, particularly during infectious disease outbreaks.

**Methods**: The study was conducted in the operating rooms of the Gynecology Clinic and Pediatric Surgery and Orthopedics Clinic of the Mureș County Emergency Clinical Hospital between March and July 2025. Air sampling was performed using the Spin Air v2 device (IUL, Barcelona, Spain), which filtered 100 liters of air per minute, and the samples were then cultured on blood agar. Samples exceeding 300 colony-forming units per cubic meter were classified as "unsuitable." Statistical analyses were performed using JASP software (v0.19.3), Wilcoxon's signed-rank test and chi-square test ($p<0.05$).

**Results**: A total of 41 samples were collected, 20 from the Gynecology Clinic and 21 from the Pediatric Surgery and Orthopedics Clinic. Fifteen samples were found to be unsatisfactory, nine of which were from the Gynecology Clinic. No significant difference was observed between the two clinics, chi-square test ($p=0.173$).

**Conclusion**: This study found a significant proportion of inadequate air quality in operating rooms. These results demonstrate the need for active air quality monitoring to reduce the risk of developing potential hospital-acquired infections.

**Keywords**: aeromicroflora, airborne pathogen, Spin Air v2 technology

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## Introduction

Nosocomial infections pose a serious challenge to healthcare facilities worldwide, as they significantly increase morbidity and mortality, particularly in high-risk areas such as intensive care units and operating rooms.[1,2] Strict control of air quality in these spaces is, essential to prevent airborne pathogens and reduce the risk of hospital-acquired infection.[3] The state-of-the-art Spin Air v2 device provides accurate measurement and analysis of microbial contamination in the air, thereby supporting targeted infection control measures. We assume that regular and accurate air sampling using the Spin Air v2 device in the critical departments of the Mureș County Emergency Clinical Hospital will enable effective monitoring of the microbial load in the air and the identification of potential sources of contamination.

Active air sampling allows for the direct quantification of viable microorganisms in the air and provides objective data on the environmental microbial load. Such data can support quality assurance processes, help identify deviations from accepted standards, and inform infrastructural or process optimization measures.

The aim of this study is to characterize the aeromicroflora found in the operating rooms of the hospital and to draw practical conclusions based on the results that may contribute to the further refinement of hygiene protocols.

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## Methods

This study aimed to assess the microbial contamination of air in two departments of the Mureș County Emergency Clinical Hospital: the operating rooms of the Gynecology, and Pediatric Surgery and Orthopedics Clinics. The research was carried out with the professional support of the Service Responsible for the Prevention of Infections Related to Hospital Healthcare from March to July 2025. Air samples were collected using a Spin Air v2 device (IUL, Barcelona, Spain) and aspiration method. The samples were taken from empty operating rooms, after the disinfection procedures were completed. During each sampling, 100 liters of air was aspirated through the device within one minute, and the samples were then inoculated on blood agar to allow the growth of heterogeneous microbial flora. Incubation was performed at 37 °C for 24 h, after which the plates were evaluated by an experienced microbiologist based on the characteristics and number of colonies. Samples with a microbial load exceeding 300 colony-forming units per cubic meter of air (CFU/m³) were classified as "unacceptable" because this concentration indicates an increased risk of infection in a hospital environment. During the study period, environmental air culture reports were routinely based on colony counts, hemolytic activity, and detection of fungal growth, without further species-level identification. The collected data were analysed in detail using JASP statistical software (v.0.19.3). During the evaluation, Wilcoxon's signed-rank test and chi-square test were used to examine differences and correlations, with a significance level of $p < 0.05$. This methodological approach ensured the reliability of the results and enabled accurate characterization of the microbial contamination of air in the clinical environments studied.

### Ethical statement

The study was approved by the Ethics Committee of the Târgu-Mureș Emergency County Hospital (letter of approval no. Ad.33272/15.01.2025).

## Results

During the entire study period, 41 air samples were collected from two different departments of the Mureș County Emergency Clinical Hospital: the Gynecology Clinic (n=20) and the Pediatric Surgery and Orthopedics Clinic (n=21). Sampling was performed according to the same protocol in both clinics, using the same equipment and under the same conditions, so that the results could be compared. Based on the aggregated data, 15 of the 41 samples tested were found to be unsatisfactory, that is, the microbial load in the air exceeded the limit value of 300 colony-forming units per cubic meter (CFU/m³). The proportion of non-compliant samples exceeded 36%, which is a remarkably high value compared to the level of sterility expected in a surgical environment. Of these samples, nine came from the operating rooms of the Gynecology Clinic and six from the Pediatric Surgery and Orthopedics Clinic. According to the results of the statistical analysis, there was no significant difference between the air quality of the two clinics ($p = 0.173$), and the frequency of "non-compliant" samples did not show a statistically significant difference ($p = 0.215$) (Table 1).

A Fisher's Exact Test was performed to determine the statistical association between the general air bioburden in the operating room of the Clinic of Gynecology and the subsequent detection of hemolytic pathogenic microbes (bacteria or fungi). The analysis revealed a pronounced relationship between the two variables (Figure 1). The Fisher's Exact Test confirmed this observation, yielding a statistically significant result ($p < 0.001$). This indicates a strong association between an air bioburden exceeding the 300 UFC/m³ threshold and the presence of hemolytic bacteria or fungi in the operating room environment.

## Discussions

The prevention of nosocomial infections increasingly relies on modern air purification technologies. Systems such as HEPA filters and UV-C-based disinfection devices have been proven to be effective in reducing microbial contamination in the air and curbing the spread of pathogens [4-5]. These technologies are particularly important in critical hospital areas, such as operating rooms, intensive care units, and isolation rooms, where the risk of infection is highest. The COVID-19 pandemic has significantly accelerated research and practice in the field of airborne-infection control. In recent years, many countries have tightened their health guidelines and introduced new protocols for the regular monitoring of hospital air quality. Regular air sampling and microbiological analyses have become mandatory in operating and closed treatment rooms, enabling the early detection of infection risks and targeted interventions [6-9]. Several factors can influence the microbial load in the air in operating rooms, including the efficiency of ventilation, maintenance of filtration systems, intensity of room use, and human traffic. Although sampling was performed in empty rooms following disinfection, variability in microbial counts was observed, suggesting that residual airborne contamination may persist due to environmental

**Table I. Summary of Air Sample Results by Clinical Department.**

| Department | Total Samples (n) | Inappropriate Samples (n) | Inappropriate Samples (%) | Mean CFU/m³ | Interpretation |
|---|---|---|---|---|---|
| Gynecology Clinic | 20 | 9 | 45.0 | ~320 | Elevated microbial load[a] |
| Pediatric Surgery and Orthopedics Clinic | 21 | 6 | 28.6 | ~290 | Within acceptable limits[b] |
| Total | 41 | 15 | 36.6 | - | - |

a.The recorded contamination levels suggest a possible need for further ventilation control; b. Although periodic review is advised.

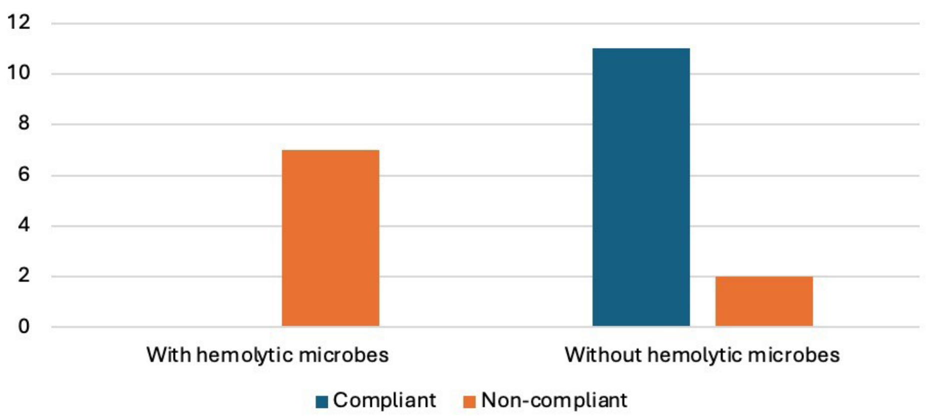


**Fig. 1. The frequency of compliant and non-compliant samples by the microbiological detection of hemolytic microbes in the Clinic of Gynecology**

or infrastructural factors. These observations show similar levels of airborne microbial contamination in both clinics, suggesting that this problem is not clinic-specific but reflects an institution-wide phenomenon. In this context, active monitoring of hospital aeromicroflora has become a key method for preventing nosocomial infections and improving patient safety. The Romanian healthcare system is gradually approaching international standards, although the modernization of infrastructure and the full introduction of new technologies remain challenges Nevertheless, a wider application is essential for the country to meet international infection control standards [10-12].Although the statistical results of the study did not show significant differences between individual clinics, the high proportion of samples with poor air quality is a serious concern. This situation necessitates a rethinking and tightening of hospital air cleanliness and infection prevention protocols, with particular attention to the maintenance of operating room ventilation systems, optimization of airflow, and reduction of human traffic during critical periods.

The variability observed between the samples may be the result of several factors. Microbial concentration can be influenced by ventilation efficiency, the condition of filter systems, the intensity of surgical activity, temperature, and humidity. In addition, the fact that certain operating rooms are used more frequently, which is associated with increased human presence and particle emissions, should not be ignored. All these factors can contribute to fluctuations in the airborne microbial load [13].

However, these observations must be interpreted considering several limitations of the current study. First, the number of air samples collected was relatively limited (n = 41), which limits the statistical power of the analysis and may affect the generalizability of the results. As a result, the observed proportions of samples exceeding the proposed microbial thresholds should be interpreted as descriptive and not representative of all operating rooms or time periods. In addition, the sampling design did not allow for robust causal inferences between airborne microbial load and environmental or procedural factors. Further studies with larger sample sizes and standardized sampling schedules are needed to confirm these observations and support broader generalizability.

Despite these limitations, the current study provides a useful snapshot of airborne microbial conditions prevailing in operating rooms in the clinical setting studied and may serve as a basis for broader environmental monitoring and quality improvement initiatives.

## Conclusion

Overall, the results of this study demonstrate that systematic and accurate monitoring of hospital air quality is an important element of healthcare safety. Regular assessment of airborne microbial load can help identify potential environmental risks early and contribute to maintaining hygienic conditions in the hospital environment. This is particularly important in critical areas such as operating rooms, where control of airborne contamination is essential. Although the current results should be interpreted with caution due to the limited sample size, they highlight the importance of air quality monitoring as part of a broader infection prevention framework. Effective infection control strategies rely on well-maintained ventilation and filtration systems, the appropriate integration of new technologies, and ongoing training of staff in infection prevention procedures. In this context, air quality monitoring should not be seen as an isolated technical measure, but as a supporting tool for quality improvement initiatives aimed at improving patient safety and the overall hospital environment.

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Generative artificial intelligence tool was used to improve English grammar (OpenAI, GPT-4), with all edits verified.

## Authors' contributions

OAZS (Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Validation; Visualization; Writing – original draft; Writing – review & editing).

FIL (Conceptualization; Formal analysis; Investigation; Methodology; Supervision; Writing – original draft; Writing – review & editing).

## Conflict of interest

None to declare.

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