ORIGINAL ARTICLE

CONTENTS

Microbiological monitoring of the hospital environment: risk assessment and strategies in infection control systems

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ABSTRACT

Aim: To investigate the role and prospects of microbial environmental monitoring in a healthcare facility, to evaluate strategies for controlling microbial contamination, to identify the species composition of microorganisms and factors that pose a threat to creating a safe environment in the facility.

Materials and Methods: A retrospective analysis of microbiological monitoring at a 200-bed healthcare facility (2020–2023) was conducted. Over 15,500 swab samples were collected from high-touch surfaces. Microorganism cultivation followed standard methods, with fungi grown on Sabouraud medium. Procedures complied with DSTU EN ISO 15189:2015 standards. The statistical reliability of relative indicators was calculated using a formula that included the standard error calculation.

Results: Microorganisms were detected in 0.8–1.9% of samples, with 162 positive environmental tests during the observation period. Staphylococcus aureus was the most common pathogen (37±3.5%), followed by Enterococcus spp. (28.4±3.2%) and Escherichia coli (16.1±2.8%). The surgical department showed the highest contamination rate (43.2±3.8%), with medical equipment in treatment rooms accounting for 61.8±3.8% of positive results.

Conclusions: The findings confirm that healthcare environments act as reservoirs for pathogens associated with healthcare-associated infections (HAIs). The surgical department exhibited the highest microbial burden, emphasizing the need for stricter infection control in high-risk areas. The predominance of Staphylococcus highlights its role in surgical site infections, with contaminated medical equipment serving as a key transmission factor. Strengthening disinfection protocols and routine monitoring is essential to mitigate microbial contamination risks.

The implementation of microbial monitoring in Ukraine depends on national standards. Routine sampling is not mandatory, with most hospitals conducting surface monitoring only during outbreaks, limiting systematic infection control efforts.

KEY WORDS: healthcare facility, Healthcare-Associated Infections (HAIs), microbiological monitoring, microorganisms, disinfection

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INTRODUCTION

Healthcare–associated infections (HAIs) are one of the greatest threats to patient safety worldwide, as they lead to increased mortality, morbidity, and length of hospital stay. The hospital environment can be a reservoir for pathogens that can persist on surfaces of medical equipment, patient environments (beds, tables, doorknobs, etc.), and on the body surfaces of patients and healthcare workers. The main cause of HAIs is poor hand hygiene among healthcare workers, with workers more likely to contaminate their hands after touching the patient environment than after direct patient contact. The main pathogens of HAIs in the hospital environment include gram–positive cocci, such as *Staphylococcus aureus* (including MRSA) and coagulase–negative staphylococci (CoNS), as well as gram–negative microorganisms, including *Escherichia coli (E. coli)*, *Pseudomonas aeruginosa* (*P. aeruginosa*), *Klebsiella pneumoniae (K. pneumoniae)*, and *Citrobacter spp.* Highly virulent pathogens, such as *Staphylococcus aureus* (methicillin–resistant *Staphylococcus aureus* or MRSA), coagulase–negative staphylococcus (CoNS), *Enterococcus species* (vancomycin–resistant enterococcus), *Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa, Clostridium difficile, and Acinetobacter baumannii*, can persist for some time on contaminated inanimate surfaces and medical equipment, significantly increasing the risk of infection transmission in healthcare settings [1].

Surfaces and engineering features of hospital wards, as well as medical equipment or other frequently used equipment, pose a risk of transmission of microorganisms in the hospital environment [2]. Surfaces in close proximity to patients are frequently contaminated by the hands of both patients and healthcare workers and are classified as high-contact surfaces [3]. Bacterial contamination of high-contact common surfaces (medical charts, doorknobs, white coats, telephones, computer keyboards/mice, handwashing sinks) and medical

equipment (blood pressure cuffs, ventilators, portable radiographic equipment, ultrasound equipment, and stethoscopes) is a serious problem in the management and treatment of patients [1,4]. Bacterial contamination of surfaces and equipment is a problem because they can serve as reservoirs for an indefinite period of time through gradual cross–transmission of pathogens and subsequent contact with patients and healthcare workers during treatment [5]. Bacterial contamination can be caused by a variety of microorganisms, including both Gram-positive and Gram-negative bacterial isolates, as well as fungal species.

Factors that contribute to the transfer of microorganisms from one surface to another include the type of organisms, the nature of the surfaces, the level of humidity, the size of the inoculum, poor hand hygiene by healthcare personnel, the number of colonized patients, and the characteristics of antibiotic administration – these factors significantly affect the risk of spreading infections in healthcare settings. According to Lucia Bonadonna Gram-negative bacteria persist longer than Gram-positive bacteria. Humidity increases the resistance of several types of bacteria (e.g., *Chlamydia trachomatis, Listeria monocytogenes, Salmonella typhimurium, Pseudomonas aeruginosa, and Escherichia coli*), while only *Staphylococcus aureus* persists longer at low humidity [6].

According to literature data 40–60% of infectious diseases developing in the intensive care unit are caused by endogenous flora, 20–40% are transmitted through contaminated hands of healthcare workers, 20–25% are due to changes caused by antibiotics, and 20% are potentially caused by environmental pollution [7]. When identifying pathogens circulating in different surgical departments, a predominance of staphylococci was found [8].

Until 2022, regular microbiological monitoring of the hospital environment was carried out in Ukraine as part of an ongoing risk assessment. The purpose of microbial monitoring of the patient's environment can be twofold: to monitor hygiene standards, namely how well a surface has been cleaned, and to investigate the presence of specific pathogens that may cause HAI outbreaks.

AIM

To investigate the role and prospects of microbial environmental monitoring in a healthcare facility, to evaluate strategies for controlling microbial contamination, to identify the species composition of microorganisms and factors that pose a threat to creating a safe environment in the facility.

MATERIALS AND METHODS

A retrospective analysis of the results of microbiological monitoring at a state security institution for the period 2020 – 2023 to assess the level of prevalence of microorganisms in different departments and the quality of cleaning and disinfection. The healthcare facility is designed for 200 inpatient beds and has an outpatient department, providing assistance to adults and children. The facility provides a full range of medical care, including primary, specialized, highly specialized, emergency, and urgent medical care.

The medical institution conducted environmental monitoring by sampling washouts from environmental objects. In total, for the period 2020 – 2023, 15,500 microbiological samples were analyzed. Samples were taken using an indirect method using tampons after cleaning hospital surfaces or medical equipment. The objects of the study were critical points that could be contaminated during the work process, in particular those places that medical personnel most often touched with their hands.

Samples were taken from surfaces that medical personnel most frequently touched with their hands. The samples were delivered to the laboratory, where each swab was placed in a liquid nutrient broth (MPB) and incubated at a temperature of 37 ± 1°C for 18 hours. After incubation, the broth was used for inoculation onto Petri dishes with a solid medium (blood agar) and incubated again at 37 ± 1°C for 48 hours. Following this, the number, appearance, size, and color of microbial colonies were evaluated. For further analysis, each type of colony was purified by subculturing on a new medium (PCA). Microorganism identification was performed using classical biochemical methods and API tests (Biomerieux, France). Sabouraud medium was used for fungal cultivation.

All stages of the study, including quality control of media, reagents, distilled water, equipment, sterilization, and laboratory conditions (temperature, humidity), were conducted by the requirements of the international standard DSTU EN ISO 15189:2015 "Medical laboratories. Requirements for quality and competence."

The statistical reliability of relative indicators was calculated using a formula that included the standard error calculation. The results were considered statistically reliable at $p<0.05$.

RESULTS

Environmental objects in healthcare facilities can be transmission factors for HAIs, especially for facilities that provide inpatient medical care, as there is a possibility of infection of both patients and medical staff.

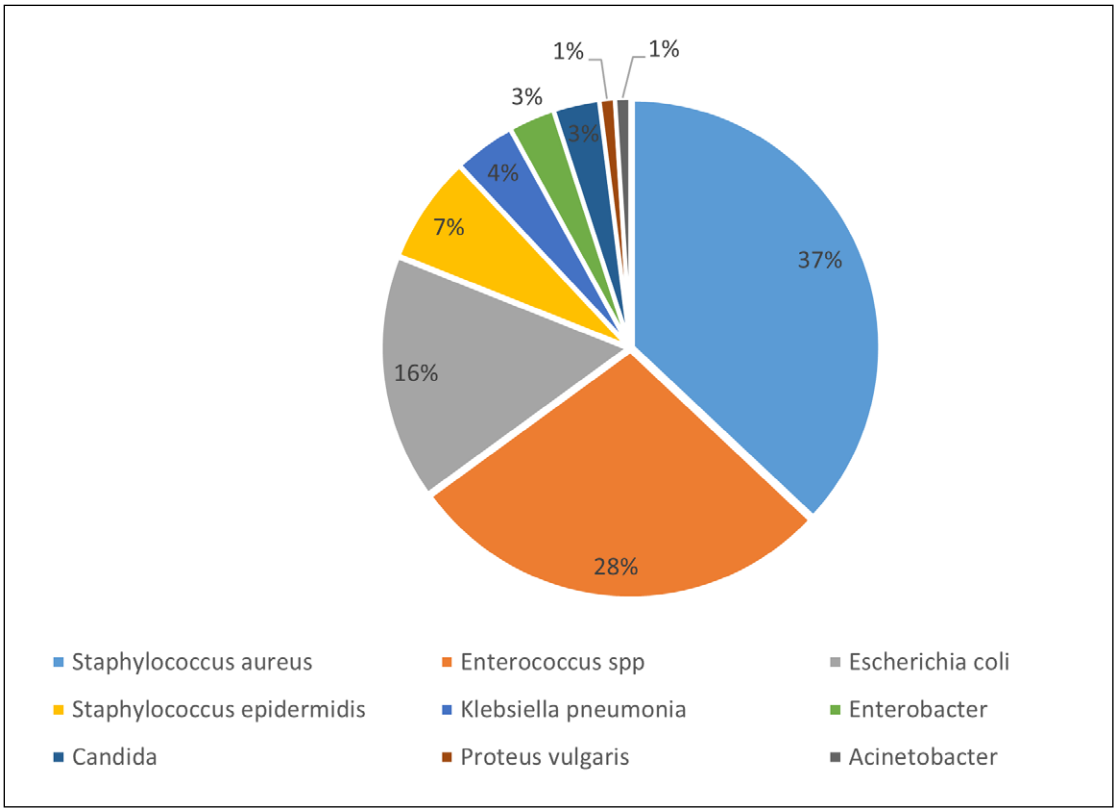

Fig. 1. Structure of identified pathogens in the hospital

The safety of the hospital environment is a critically important aspect that encompasses several areas to protect the health of patients, medical staff, and visitors. Proper cleaning and disinfection requires the removal of dirt and pathogens to minimize the risk of infection to patients in the hospital environment. An important component of effective cleaning in hospitals until 2022 was the microbiological monitoring of the effectiveness of the cleaning and disinfection methods used. Visual assessment is usually the recommended tool for monitoring cleaning effectiveness. Monitoring environmental cleaning using visual assessment is insufficient in practice. Microbiological monitoring of surfaces provided information for optimizing sampling scenarios, an algorithm for high–quality cleaning and disinfection of the most contaminated surfaces.

As a result of microbiological studies, positive results were found, namely opportunistic pathogens. It should be noted that no pathogenic pathogens were detected. In total, 162 positive results were detected during environmental studies during the observation period (2020–2023). The number of positive results in the environment in 2020 was 1.9±0.4% of the total number of studies conducted, in 2021 – 1.0±0.3%, in 2022 – 0.8±0.2% and in 2023 – 1.5±0.3%. In the structure of detected pathogens, the largest share is *Staphylococcus aureus* – 37±3.5%, in second place is *Enterococcus spp.* – 28.4±3.2%, *Escherichia coli* – 16.1±2.8%, *Enterobacter* – 3.1±1.3%, *Klebsiella pneumonia* – 4.3±1.5%, *Proteus vulgaris* and *Acinetobacter* 0.6±0.2% each, *Staphylococcus epidermidis* – 7.4±2.01% and fungi *Candida*– 2.5±1.2%. (Fig. 1).

An analysis of positive results was conducted according to the profile of structural units, which were divided into 4 groups: surgical hospital with operating and intensive care units; children's hospital; maternity ward and outpatient department. In the structure of positive results, it was found that the most positive results were obtained in the surgical hospital – 43.2±3.8%, in the children's hospital – 15.4±2.7%, in the maternity ward – 12.9±1.6% and in departments where outpatient reception is carried out – 28.4±3.3% (Fig. 2)

An analysis of the species composition of pathogens was carried out according to different profiles of the departments (Table 1) and it was established: in the surgical hospital, *Staphylococcus aureus* prevails – 30±5.4% and *Enterococcus spp.* – 24.3±5.1%; in the maternity hospital – *Enterococcus spp.* – 42.6±7.3%; in the children's hospital – *Staphylococcus aureus* – 52±9.7% and in the departments where outpatient admission is carried out – *Staphylococcus aureus* – 45.7±7.3%.

Analysis of the annual dynamics of the detection of microorganisms in the hospital environment showed that the majority of positive results were detected in

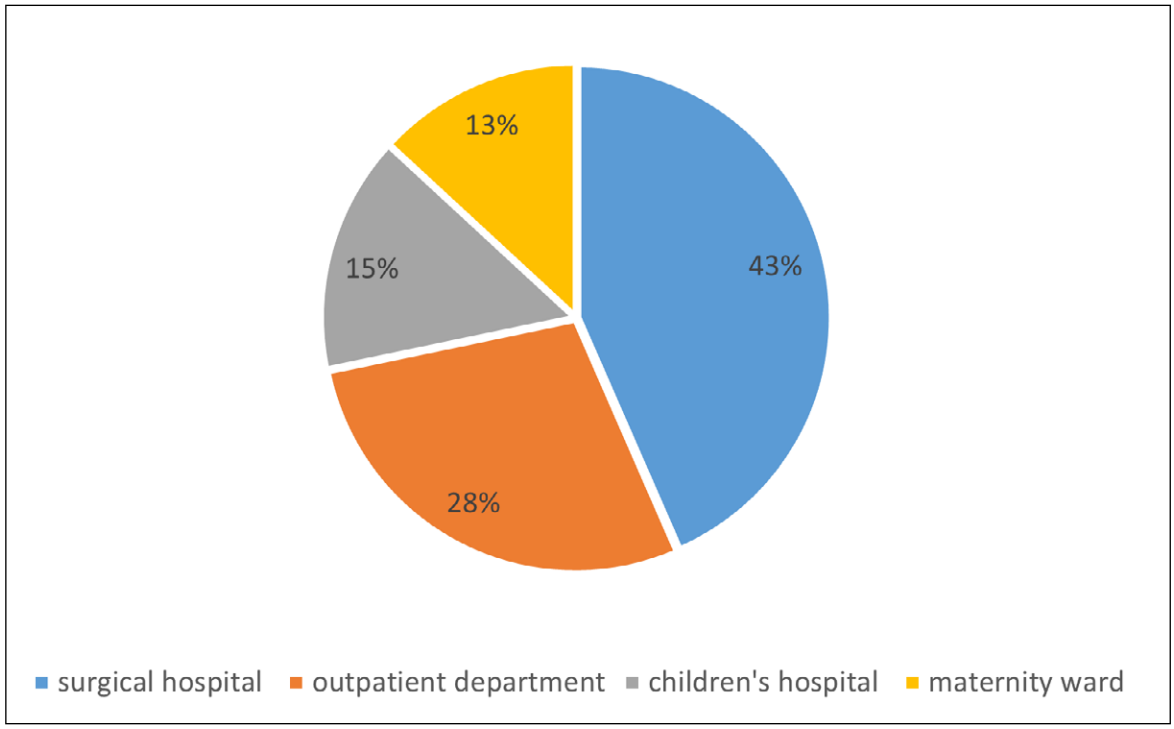

Fig. 2. Distribution of detected pathogens by structural units

Table 1. Distribution of microorganisms by hospital structural unit profiles (%)*

	surgical hospital n-70	maternity ward n-21	outpatient department n-46	children's hospital n-25
St.epidermitis	15.7±1.8	–	–	4.0±0.7
E. coli	15.7±1.8	23.9±5.1	10.9±1.5	20.0±3.8
St. aureus	30.0±3.5	23.9±5.1	45.7±6.6	52.0±10.3
Enterobacter	1.4±0.1	9.5±1.9	2.2±0.1	4.0±0.7
Enterococus spp.	24.3±2.8	42.6±9.2	36.9±5.4	12.0±2.3
Kl. pneumonia	7.1±0.8	–	–	8.0±1.5
Candida albicans	2.9±0.3	–	4.3±0.5	–
Acinetobacter	1.4±0.1	–	–	–
Proteus vulgaris	1.4±0.1	–	–	–

* The results were considered statistically reliable at $p<0.05$

the warm season. Namely, 41% of microorganisms were detected in June and 10% in July and October. It should be noted that in August the number of patients in the institution decreases.

The objects on which microorganisms were detected were conditionally divided into three groups: medical equipment located in treatment rooms and operating rooms (medical tables, medical cabinets, panmeds, bixes, examination chairs, refrigerators, etc.); medical equipment located in the wards where patients are (bedside tables, tripods, table, bedside table); medical clothing and hands of staff. Analysis of the results showed that the most positive results were found on medical equipment in treatment rooms – 61.8±3.8%, in the wards – 20.8±3.1%, on medical clothing and hands of staff – 17.2±2.9% (7.9± 2.1% on clothing and 9.3±2.3% on hands).

DISCUSSION

The study suggests that the hospital environment can potentially facilitate the transmission of pathogens HAIs. Although the proportion of detected microorganisms in environmental objects in the hospital for 2020–2023 is insignificant and amounted to 0.8% to 1.9%. In total, 162 isolated microorganisms were detected, which indicates the presence of potential risks. Analysis of the detected pathogens showed that the most *Staphylococcus aureus* –37±3.5%, which coincides with the results of other studies, in which up

to *Staphylococcus* belonged to 40%. In second place, *Enterococcus spp* detected – 28.4±3.2%, which does not coincide with the literature data, where the share of this microorganism is 3% [9]. In third place is *Escherichia coli* – 16.1±2.8%. Also found were *Enterobacter, Klebsiella pneumonia, Proteus vulgaris, Acinetobacter, Staphylococcus epidermidis* and fungi *Candida*. According to literature data, these pathogens are present in the hospital environment [8, 9].

Regarding the distribution of microorganisms by profiles of hospital structural units: the largest number of microorganisms was detected in a surgical hospital with operating and intensive care units – 43.2±3.8%, in the maternity ward 12.9±1.6% were isolated. The distribution of microbes by profiles established that Staphylococcus aureus prevailed in all structural units, except for the maternity ward, where the largest proportion was *Enterococcus spp.*

We observed a pronounced seasonality from June to October with a peak in June, which accounted for 41% of all microbes detected. This situation may lead to an increase in the number of HAI cases. According to other studies, during the summer months there is an increase in the average infection rate at 28% [10].

Regarding the objects on which microorganisms were detected, 61.8±3.8% were in rooms where operations, dressings and other medical manipulations are performed, namely on medical tables (anesthesiologist's table, nurse's table) microorganisms were detected in 23.2±3.1% among medical equipment objects. According to other studies, microorganisms were also found on medical equipment, including in 10% of cases on the medical table [11].

CONCLUSIONS

The study confirmed that the hospital environment can be a reservoir of pathogens associated with the provision of medical care. The largest number of pathogens was found in the surgical hospital, which emphasizes the need to strengthen control over the hospital environment objects in high-risk areas, especially during the period of seasonal increase in the activity of microorganisms. Information was obtained on the species composition of microorganisms circulating in the department of various profiles, the identification of which revealed the predominance of Staphylococcus, which can cause infection of the surgical site.

Medical equipment contaminated with microorganisms can be transmission agents for HAIs.

Pathogens Healthcare–associated infections that occur in the hospital environment should be monitored in epidemiological surveillance programs. Infection control programs focus on epidemiological surveillance of microorganisms recognized as pathogenic, both on biotic and abiotic surfaces; however, infections can continue to evolve. Thus, understanding the species composition of microorganisms in the hospital environment can help identify variations that contribute to the development of infection, including predicting the risk of outbreaks. These efforts can be part of what, together with epidemiological surveillance, surface cleaning, disinfection and proper hand hygiene programs, and the implementation of antibiotic stewardship programs, will provide effective approaches to prevent healthcare–associated infections.

Strategies to control microbial contamination should include regular cleaning and disinfection of surfaces, training of healthcare staff in hygiene practices, especially hand hygiene, use of modern disinfectants, and implementation of monitoring systems to assess the effectiveness of the measures taken. This will minimize the risk of infection and create a safe environment for patients and staff.

The prospects for the implementation of microbial monitoring in Ukraine are related to national standards. Currently, microbiological monitoring is not mandatory, and samples from hospital facilities are usually taken only in the event of an outbreak of infections. Routine sampling is not provided for in medical institutions, since microbiological monitoring of surfaces is not enshrined in regulatory acts. Hospitals that decide to conduct such studies are guided by internal recommendations, which limits a systematic approach to infection control in the hospital environment.

REFERENCES

1. Russotto V, Cortegiani A, Raineri SM, Giarratano A. Bacterial contamination of inanimate surfaces and equipment in the intensive care unit: A systematic review. J Intensive Care. 2015;3(1):54. doi: 10.1186/s40560-015-0120-5. DOI
2. Ez Zoubi Y, Farah A, Zaroual H et al. Antimicrobial activity of Lavandula stoechas phenolic extracts against pathogenic bacteria isolated from a hospital in Morocco. Vegetos. 2020;33(4):703–711. doi: 10.1007/s42535-020-00160-3. DOI
3. Berrada S, Touimi GB, Bennani L, Lyoubi M. Exploration microbiologique des surfaces d'un centre d'hémodialyse de la ville de Fès: étude descriptive transversale. Rev Francophone Int Rech Infirm. 2017;3(2):120–128. doi: 10.1016/j.refiri.2017.03.001. DOI
4. Chaka T, Misgana G, Feye B, Kassa R. Bacterial isolates from cell phones and hands of health care workers: A cross-sectional study in pediatric wards at Black Lion Hospital, Addis Ababa, Ethiopia. J Bacteriol Parasitol. 2016;7(4). doi: 10.4172/2155-9597.1000288. DOI

5. Mann EE, Manna D, Mettetal MR et al. Surface micropattern limits bacterial contamination. Antimicrob Resist Infect Control. 2014;3(1). doi: 10.1186/2047-2994-3-28. DOI
6. Bonadonna L, Briancesco R, Coccia AM. Analysis of microorganisms in hospital environments and potential risks. Indoor Air Quality in Healthcare Facilities. Springer International Publishing. 2017, p. 53–62. doi: 10.1007/978-3-319-49160-8_5. DOI
7. Weber DJ, Anderson D, Rutala WA. The role of the surface environment in healthcare-associated infections. Curr Opin Infect Dis. 2013;26(4):338–344. doi: 10.1097/QCO.0b013e3283630f04. DOI
8. Flouchi R, Elmniai A, El Far M et al. Microbiological monitoring of the environment using the "association rules" approach and disinfection procedure evaluation in a hospital center in Morocco. J Environ Public Health. 2021;2021(1):1–9. doi: 10.1155/2021/7682042. DOI
9. Richet H. Seasonality in Gram-negative and healthcare-associated infections. Clin Microbiol Infect. 2012;18(10): 934–940. doi: 10.1111/j.1469-0691.2012.03954.x. DOI
10. Perencevich EN, McGregor JC, Shardell M et al. Summer peaks in the incidences of Gram-negative bacterial infection among hospitalized patients. Infect Control Hosp Epidemiol. 2008;29(12): 1124–1131. doi: 10.1086/592698. DOI
11. Onifade EO, Ogbonna IO, Ikwebe J et al. Bacteriological assessment of hospital air and selected surfaces in three referral hospitals in Makurdi Middle Belt Nigeria. Eur J Environ Public Health. 2020;4(2): em0056. doi: 10.29333/ejeph/8454. DOI

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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