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Comparison of Airborne Flora Before and After Learning Activities in Skill Lab and Tutorial Rooms at the Faculty of Medicine, Yarsi University, and a Review From an Islamic Perspective

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KEYWORDS
Indoor air quality, air flora, microorganisms, skill lab room, tutorial room.

ABSTRACT
Indoor Air Quality (IAQ) significantly affects health and concentration in educational environments. Factors such as learning activities, population density, and ventilation systems influence the presence of airborne microorganisms. This research aims to compare the airborne flora before and after learning activities in the Skill Lab and Tutorial rooms at the Faculty of Medicine, YARSI University, and to analyze the findings from an Islamic perspective. A descriptive qualitative–quantitative method was applied, with 20 samples collected using the settle plate method on Nutrient Agar media. Samples were incubated at 35–37°C for 48 hours, and the bacterial colonies were then counted (CFU) and identified using Gram staining. The results show that the number of airborne microorganisms in five Skill Labs and five Tutorial rooms remained below the standard threshold for air quality (<700 CFU/m³). However, there was a noticeable increase in the number of colonies after learning activities, with the lowest value recorded at 0 CFU/m³ and the highest at 13 CFU/m³. This increase is suspected to be related to human activity, density, and mobility during class sessions. Microscopic identification revealed the predominance of Gram-positive Coccus bacteria, with some Gram-negative rods. In conclusion, the number of airborne microorganisms in the Skill Lab and Tutorial rooms at the Faculty of Medicine, YARSI University, is still within the quality standard, although learning activities contribute to an increase in colony numbers. Therefore, optimal management of the room environment is necessary to maintain good air quality.

INTRODUCTION

Indoor Air Quality (IAQ) is an important factor that affects the comfort, health, and productivity of occupants. In the educational context, maintaining good air quality in Skill Lab and Tutorial rooms is a major concern because it is directly related to respiratory health and students' ability to concentrate (Cincinelli & Martellini, 2017). Non-specific symptoms such as cough, headache, eye irritation, and fatigue are often associated with poor air quality in non-industrial buildings such as offices and campuses (Langiano et al., 2024).

Three main components significantly influence Indoor Air Quality (IAQ), namely outdoor air quality, human activities within buildings, and building materials, equipment, and furniture (Tran et al., 2020). The learning process in Skill Lab and Tutorial rooms typically involves intensive interaction between students and educators, accompanied by the use of various tools and materials. Crowded room conditions and the use of such equipment can affect air circulation quality and the presence of airborne flora. Research by Fujiyoshi et al. (2017) shows that distance between individuals, movement, and the use of classroom equipment can influence the distribution of airborne microorganisms.

Building features such as natural ventilation also play an essential role in influencing airborne flora, alongside human activities. Natural ventilation is considered superior because it reduces the concentration of microorganisms commonly found in air-conditioned spaces, where high humidity can promote microbial accumulation. Natural ventilation allows fresh outdoor air to enter and replace contaminated air, thereby lowering the concentration of pathogens in the indoor environment. In contrast, air conditioners that are not properly maintained can increase the number of airborne particles and microorganisms due to closed air circulation. Research indicates that 15 colonies of airborne microorganisms were found with a maximum of 81 CFU/m³ in an air-conditioned room, while a naturally ventilated room contained 8 colonies with a total of 74 CFU/m³ (Walid et al., 2019). Moreover, natural ventilation is believed to enhance the productivity and concentration of both students and educators during learning activities in Skill Lab and Tutorial rooms (Cincinelli & Martellini, 2017).

The presence of microorganisms in Skill Lab and Tutorial rooms is inevitable because indoor air contains a complex mixture of biological contaminants such as bacteria, fungi, viruses, and algae, as well as their by-products, including endotoxins and mycotoxins. Factors such as temperature, humidity, and ventilation strongly affect the spread of these microorganisms. Although air is not an ideal medium for microbial growth, fungal spores and bacteria can survive in the air for a certain period. The spread of indoor microorganisms can pose health risks such as allergies, respiratory infections, and other communicable diseases (Kumar et al., 2021).

The increase in microorganisms can be minimized through measures to maintain cleanliness. In Islam, cleanliness (taharah) is an integral part of health, and Allah loves His servants who maintain purity. Cleanliness in Islamic teachings encompasses both external and internal aspects. The external aspect is reflected through practices of taharah, such as ablution (wudu), mandatory bathing (ghusl), and maintaining personal hygiene, clothing, and the environment, while the internal aspect pertains to the purity of the heart and soul. Allah SWT says in the Qur'an (Nuralifya et al., 2024).

اِنَّ اللّٰهَ يُحِبُّ التَّوَّابِيْنَ وَيُحِبُّ الْمُتَطَهِّرِيْنَ

Meaning: "*Indeed, Allah loves those who repent and loves those who purify themselves*." (QS. Al-Baqarah/2:222)

The verse emphasizes that humans are commanded to always maintain personal and environmental cleanliness. This is in line with the Islamic teachings that Allah SWT loves beauty and cleanliness (Andriyani, 2019) .

Good air quality in the learning space to support the health and comfort of academics and educators is essential. Research on the air flora in the learning room of the Faculty of Medicine,

YARSI University has never been conducted. Therefore, in this study, the researcher aims to compare the air flora before and after learning in the *skill lab* room and tutorial of the Faculty of Medicine, YARSI University. This research is expected to provide benefits for various parties. For students, it can broaden their insight into airborne flora and the factors that contribute to its increase, enabling them to better understand the importance of air quality and take preventive measures to support the sustainability of learning activities in the Skill Lab and Tutorial rooms at the Faculty of Medicine, YARSI University. For YARSI University, this research provides information regarding airborne flora in the Skill Lab and Tutorial rooms and the factors influencing its increase, which can be used to improve air quality in learning spaces and create a healthier environment for students. For researchers, this study provides an opportunity to carry out research and expand knowledge by applying the knowledge gained during education at YARSI University.

METHOD

This study is a descriptive qualitative–quantitative study that aims to describe the increase in airborne flora and colonies in the Skill Lab and Tutorial rooms of the Faculty of Medicine, YARSI University. It also aims to describe and analyze legal norms and applicable legal rules, relating them to existing social practices or phenomena (Tan, 2021). This method focuses on the analysis of secondary data such as legislation, books, and journals, using a qualitative approach to systematically and comprehensively describe legal issues from the perspective of theory and legislation. Normative legal research data consist of secondary data obtained from literature studies and are divided into primary, secondary, and tertiary legal materials (Ariawan, 2013). Primary legal materials include legislation, the constitution, and jurisprudence, while secondary legal materials consist of books, journals, and previous research findings. Tertiary legal materials include legal dictionaries and encyclopedias. All collected data are analyzed qualitatively to systematically process, classify, and present an overview or explanation of the research subject or object (Rijali, 2018). The analysis does not rely on numerical or frequency data but instead on patterns, theoretical comparisons, and legal logic arguments.

The research design involves sampling airborne flora in the Skill Lab and Tutorial rooms of the Faculty of Medicine, YARSI University. Sampling was conducted in the morning before room use and in the afternoon after learning activities. Samples were cultured in Petri dishes containing Nutrient Agar (NA) media using the settle plate technique (passive sampling method) and repeated twice for each sampling. Bacterial cultures were conducted to identify bacterial types and determine the increase in airborne flora. The data obtained were analyzed quantitatively and descriptively to assess the number of colonies and the increase in airborne flora in both types of rooms. The study population consisted of all airborne flora in the Skill Lab and Tutorial rooms, while the sample included airborne flora collected over several days at central room positions to ensure sampling quality. This research was conducted over five days, both before and after learning activities. The number of samples was determined using the Slovin formula with a 5% margin of error, yielding a total of 20 samples to obtain representative data on airborne flora in the Skill Lab and Tutorial rooms of the Faculty of Medicine, YARSI University.

In the univariate analysis, the number of microbial colonies growing in the air was analyzed descriptively at two time points—before and after learning activities in the Skill Lab and Tutorial rooms. This analysis aimed to describe the distribution of airborne flora in each room and to observe changes in colony numbers after learning activities. The results of the analysis were presented in tabular form to provide a clear representation of the differences in the amount of airborne flora under each condition.

RESULTS AND DISCUSSIONS

This study used a total of 20 samples collected from ten different rooms at the Faculty of Medicine, YARSI University, consisting of five Skill Lab rooms and five Tutorial rooms, with each room sampled at two different times. The rooms used as sampling points in the Skill Lab area included Skill Lab 1B, Skill Lab 3B, Skill Lab 4A, Skill Lab 4C, and Skill Lab 5B, while the Tutorial rooms consisted of Tutorial Room 01, Tutorial Room 05, Tutorial Room 12, Tutorial Room 16, and Tutorial Room 23. All samples were then cultured to observe the growth of airborne flora, based on both the number of colonies formed in the culture medium and the morphological characteristics of the colonies. The description of airborne flora was conducted through macroscopic observation of colony shape, color, and texture, and microscopic analysis using Gram staining. The data obtained in this study were analyzed using the total cell count method. A detailed description of each research dataset is presented and discussed in the following sections.

Number of colonies of aerial flora

The calculation of colonies of aerial flora using the Total Cell Count Method aims to calculate the total colonies of aerial flora that grow using the Nutrient Agar Plate (NAP) medium. This procedure is carried out by implanting bacteria in Nutrient Agar media, then incubating at a temperature of 37 □C for 24 hours.

Table 1. Data on the Number of Colonies of Aerial Flora in the Tutorial Room

Ruangan	Before	After
Tutorial 01	1 CFU	4 CFU
Tutorial 05	0 CFU	8 CFU
Tutorial 12	10 CFU	16 CFU
Tutorial 16	2 CFU	6 CFU
Tutorial 23	3 CFU	7 CFU

Source: Primary data from the study, 2026

Table 2. Data on the Number of Colonies of Air Flora in the Clinical Skill Lab Room

Ruangan	Before	After
***Skill lab* 1B**	0 CFU	16 CFU
***Skill lab* 3B**	4 CFU	10 CFU
***Skill lab* 4A**	1 CFU	5 CFU
***Skill lab* 4C**	3 CFU	6 CFU
***Skill lab* 5B**	4 CFU	2 CFU

Source: Primary data from the study, 2026

The test results showed that the number of airborne microorganisms in the Skill Lab and Tutorial rooms of the Faculty of Medicine, YARSI University, met air quality standards (i.e.,

less than 700 CFU/m³). However, data analysis indicated a significant increase in the number of airborne flora colonies in the Skill Lab and Tutorial rooms after learning activities, particularly in rooms located at the end of hallways or main circulation routes, such as Tutorial 12, Tutorial 16, Tutorial 23, and Skill Lab 1B and Skill Lab 4A. This condition is believed to be related to the high mobility of students and educators moving through these areas, which increases the release of bioaerosols into the air. These findings are consistent with a study conducted by Wismana (2016), which showed significant variations in the number of airborne microbes before and after surgery. The number of microbes recorded before surgery was 12 CFU/m³, increasing to 107 CFU/m³ after surgery. In addition, bacterial concentrations were found to be higher in the afternoon than in the morning, suggesting that human activity contributes to the increase in airborne microorganisms in indoor environments.

This aligns with research by Kurniawan et al. (2021), which stated that the number of bacterial colonies present in indoor air depends heavily on the type and intensity of human activity taking place. The variety and intensity of these activities directly influence the density and growth of microorganisms in the room's environment. Research by Li et al. (2022) also confirmed that room density, number of occupants, and environmental factors can increase airborne microbial contamination. In the context of this study, each Skill Lab and Tutorial room was occupied by ten students and one educator, with a learning duration of 2 × 50 minutes, resulting in a cumulative total of 40 students per day per room. This occupancy factor strongly influences air flora quality, as it directly affects room temperature and humidity levels, which in turn encourage bacterial growth and spread (Pratiwi et al., 2024).

Most of the rooms exhibited an increase in the number of airborne flora colonies; however, Skill Lab 5B showed different results, as presented in Table 4, indicating a decrease in the number of colonies after the Skill Lab activities. These findings suggest variations in environmental conditions that warrant further evaluation. The decrease is thought to have been influenced by immediate post-activity cleaning or by non-optimal microbial growth during the incubation process. This finding is supported by the study of Sentosa and Hapsari (2019), which reported a decrease in the number of airborne bacterial colonies in an operating room after cleaning—from 32 CFU/m³ before cleaning to 18 CFU/m³ afterward.

Description of Colony of Aerial Flora

Table 3. Data Results of Description of Aerial Flora Colonies in the Tutorial Room and ***Skill Lab Room***

Ruangan		Sample code	Macroscopic identification of air flora in NAP media	Microscopic identification of air flora on Gram staining	Approximate types of aerial flora
Tutorial 01	Before	A1	White, *smooth*, round	*Gram-negative* coccus	*Neisseria sp.*
	After	B1	White, mucoid, round	*Diplococcus*, Gram-negative	*Neisseria sp.*
		B2	Yellow, *rough*, rounded uneven edges	*Gram-negative* coccus	*Micrococcus sp.*
		B3	Solid white, *smooth*, round	*Gram-negative* coccus	*Acinetobacter sp.*
Tutorial 05	Before	Sterile	Sterile	Sterile	-

Ruangan		Sample code	Macroscopic identification of air flora in NAP media	Microscopic identification of air flora on Gram staining	Approximate types of aerial flora
	After	B4	White, mucoid, round	*Gram-negative* coccus	*Acinetobacter sp.*
		B5	Yellowish-white, *rough*, rounded uneven edges	*Gram-positive* Diplococcus	*Streptococcus sp.*
		B6	White, *rough*, round	*Coccus*, Gram negative	*Neisseria sp.*
		B7	White, *smooth*, round	*Diplococcus* Gram-negative	*Neisseria sp.*
Tutorial 12	Before	A1	Yellow, mucoid, round	*Gram-positive* Streptococcus	*Streptococcus sp.*
		A2	Milky white, *rough*, rounded uneven edges	Diplobasil Negative Gram	*Enterobacter sp.*
	After	B1	Solid yellow, mucoid, round	*Diplococcus* Gram-negative	*Neisseria sp.*
		B2	Yellowish-white, *rough*, rounded uneven edges	*Gram-positive* Diplococcus	*Streptococcus sp.*
		B3	Milky white, *smooth*, round	*Gram-negative* coccus	*Acinetobacter sp.*
		B4	Milky white, mucoid, round	*Coccus*, Gram negative	*Neisseria sp.*
Tutorial 16	Before	A1	White, mucoid, round	*Gram-negative* coccus	*Acinetobacter sp.*
	After	B1	Yellow, *rough*, rounded uneven edges	*Gram-positive cluster* coccus	*Staphylococcus sp.*
		B2	Yellowish-white, *smooth*, round	Diplobasil Negative Gram	*Enterobacter sp.*
		B3	Yellow, mucoid, round	*Gram-positive cluster* coccus	*Staphylococcus sp.*
		B4	White, *smooth*, round	Basil, Gram-negative	*Enterobacter sp.*
Tutorial 23	Before	A1	White, mucoid, round	*Gram-negative* streptococcus	*Streptococcus sp.*
		A2	Yellow, mucoid, round	Basil, Gram positive	*Bacillus sp.*
		A3	White, *rough*, round uneven	*Diplococcus*, Gram-negative	*Neisseria sp.*
	After	B1	Yellow, mucoid, round	*Coccus*, Gram negative	*Neisseria sp.*
		B2	Milky white, *rough*, rounded uneven edges	*Gram-positive cluster* coccus	*Staphylococcus sp.*
		B3	Yellow, *smooth*, round	Basil, Gram positive	*Bacillus sp.*
		B4	White, *smooth*, round	Basil, Gram-positive and *Gram-positive* Diplococcus	*Bacillus sp.* & *Streptococcus sp.*
***Clinical Skill Lab* 1B**	Before	sterile	sterile	sterile	
	After	B1	White, *rough*, rounded uneven edges	Basil, Gram positive	*Bacillus sp.*

Ruangan		Sample code	Macroscopic identification of air flora in NAP media	Microscopic identification of air flora on Gram staining	Approximate types of aerial flora
		B2	White, mucoid, round	*Gram-negative* coccus	*Acinetobacter sp.*
		B3	Yellow, mucoid, round	*Gram-positive coccus* and *Gram-negative* treptococcus	*Staphylococcus sp.* & *Streptococcus sp.*
		B4	White, *smooth*, round	Streptobacilli, Gram-negative	*Enterobacter sp.*
***Clinical Skill Lab* 3B**	Before	A1	White, mucoid, round	*Gram-positive cluster* coccus	*Staphylococcus sp.*
	after	B1	Milky white, mucoid, round	*Gram-positive cluster* coccus	*Staphylococcus sp.*
		B2	Yellow, mucoid, round	*Gram-positive cluster* coccus	*Staphylococcus sp.*
***Clinical Skill Lab* 4A**	Before	A1	White, mucoid, round	*Gram-positive cluster* coccus	*Staphylococcus sp.*
	after	B1	Milky white, *smooth*, round	Basil, Gram-negative	*Enterobacter sp.*
		B2	Yellow, mucoid, round	*Gram-negative* diplococcus and *Gram-positive group* Coccus	*Neisseria sp.* & *Staphylococcus sp.*
***Clinical Skill Lab* 4C**	Before	A1	Milky white, mucoid, round	*Gram-negative* coccus	*Acinetobacter sp.*
		A2	Yellow, *rough*, rounded uneven edges	*Gram-positive cluster* coccus	*Staphylococcus sp.*
	after	B1	Yellowish-white, mucoid, round	Gram-negative streptobacles and *Gram-negative* Coccus	*Pseudomonas sp.* & *Acinetobacter sp.*
		B2	White, *smooth*, round	Gram-negative streptobacillin	*Enterobacter sp.*
***Clinical Skill Lab* 5B**	Before	A1	White, *smooth*, round	When the bacteria are not growing	-
		A2	White, *rough*, rounded uneven edges	When the bacteria are not growing	-
	after	B1	White, *smooth*, round	*Gram-negative* coccus	*Acinetobacter sp.*

Source: Primary data from the study, 2026

Descriptions of the colonies of airborne flora growing on culture media in the Skill Lab and Tutorial rooms of the Faculty of Medicine, YARSI University, show variations in the shape, color, and surface characteristics of the colonies, as presented in Table 5. In general, the colonies observed exhibited spherical morphology with smooth or rough surfaces and, in some samples, mucoid consistency. The colony colors varied between white, milky white, and yellow.

Gram-positive Coccus and Gram-negative Coccus bacteria were dominant in both the Skill Lab and Tutorial rooms of the Faculty of Medicine, YARSI University. The presence of

Gram-positive Coccus bacteria is consistent with the characteristics of normal human skin flora, particularly Staphylococcus sp. This finding indicates that the primary source of air contamination in the rooms originates from human activities. The layout of the rooms also contributed to the detection of Staphylococcus sp. in several locations—namely Tutorial 23, Tutorial 16, and Clinical Skill Lab 1B and 4A. These rooms are located at the end of hallways, which serve as circulation routes for students and educators, resulting in higher human activity and increased risk of airborne contamination. According to research by Fithri et al. (2016), the presence of such bacteria in classrooms is strongly influenced by desquamation (skin cell shedding) and bioaerosols released when room occupants speak or move. Similarly, Sari and Soleha (2020) also identified Staphylococcus sp. as the most prevalent bacterium in indoor air samples, reinforcing the conclusion that human activity is a major source of indoor microbial contamination.

Microscopic identification also revealed the dominance of Gram-negative Coccus bacteria suspected to be Neisseria sp., a group of microorganisms often found on furniture and equipment in Skill Lab and Tutorial rooms. The presence of these bacteria on surfaces such as tables and chairs corresponds with findings by Japanto et al. (2016), who identified Gram-negative Coccus groups on inanimate objects. The existence of such bacteria on furniture surfaces is influenced by several factors, including suboptimal sanitation practices—such as improper disinfectant dosage, ineffective cleaning methods, and irregular cleaning schedules. In addition to hygiene factors, the presence of Gram-negative Coccus bacteria may also be affected by external factors such as occupant mobility and the presence of insects.

Microscopic identification further showed the presence of Gram-negative rod-shaped colonies in Tutorial 12, Tutorial 16, and Skill Lab 4C, suspected to be Enterobacter sp. and Pseudomonas sp. These bacteria can spread easily among humans through contaminated hands, indicating external contamination and poor air circulation. The Skill Lab and Tutorial rooms at the Faculty of Medicine, YARSI University, rely entirely on air conditioning (AC) systems without natural ventilation. Enclosed spaces without adequate air exchange tend to trap microorganisms within the circulation system. Research by Surfa et al. (2024) found that Gram-negative rod-shaped bacteria frequently proliferate in air conditioning systems that lack regular maintenance or cleaning. Accumulated dust and moisture in AC units create an ideal environment for bacterial growth, which over time may increase the risk of Sick Building Syndrome (SBS) among students and educators who spend prolonged periods in such environments. In addition to air circulation factors, the presence of rod-shaped bacteria also results from external contamination. This aligns with the findings of Li et al. (2022), who stated that microorganisms are often carried into learning spaces through clothing, shoes, or dust particles carried by occupants, especially during movement.

Variations in the morphology and types of airborne bacteria are influenced by multiple environmental and behavioral factors, including the frequency of room entry and exit, occupant density, cleanliness and maintenance of ventilation or air conditioning systems, room humidity, accumulated dust on furniture or tools, and the duration of learning activities. Research by Walid et al. (2019) suggests that air-conditioned rooms have a higher likelihood of harboring microorganisms when maintenance practices are inadequate. Moreover, activities such as speaking, moving chairs, using educational tools, and friction from clothing can further increase

microbial dispersal. Sahli et al. (2021) also highlighted that insufficient room hygiene protocols contribute to greater bacterial growth compared to sterile environments such as operating rooms. Therefore, maintaining room hygiene must be conducted continuously—through adequate ventilation in Tutorial and Skill Lab rooms, installation of air purifiers to filter airborne microorganisms, regular cleaning of floor surfaces, routine maintenance of air conditioning systems, and hygiene awareness education for students and educators who interact with medical equipment.

CONCLUSION

Based on the results of the research and discussion comparing airborne flora before and after learning activities in the Skill Lab and Tutorial rooms of the Faculty of Medicine, YARSI University, and its review from an Islamic perspective, the following conclusions were obtained: There is a difference in the number of airborne flora colonies before and after learning activities in the Skill Lab and Tutorial rooms of the Faculty of Medicine, YARSI University. The number of colonies increased after learning activities, but the values remained within air quality standards according to Minister of Health Regulation Number 48 of 2016, which stipulates a maximum of 700 CFU/m³. The morphological description of the colonies showed variations in airborne flora, with a predominance of Gram-positive and Gram-negative Coccus bacteria corresponding to normal human flora, and some rod-shaped bacteria indicating contamination from the external environment.

The teachings of Islam align with the principles of medical science. Both Islam and medicine recognize the existence of microorganisms and uphold cleanliness as a preventive measure—through both health protocols and the concept of taharah. Furthermore, Islam encourages scientific research as a means of deepening knowledge and understanding of Allah SWT's creation.

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