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Comparison between indoor air quality of private and governmental health care institutions

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***Abstract*---**Background: Indoor air quality is "of interest" to healthcare providers because of its importance in maintaining the health of internal and external customers, as the air can transmit various microbes, including pathogenic ones. Objectives: This study aimed to investigate Indoor air quality in private and governmental healthcare institutions in Nablus -Palestine. As well as compare the results before and during the COVID-19 Pandemic; by finding the effect of adhering to the public health and safety guidelines imposed by the Ministry of Health. Methods: Samples were collected by passive approach from two different hospitals at five departments where most activities and tasks are performed inside, Besides two –various sites outside the hospital, in an average of three hours. The positive colonies were identified by using several biochemical tests. Then, the Total Microbial Load (CFU/plate) was calculated for each plate. Results: The predominant Gram-positive bacteria in Rafidia

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Governmental Surgical Hospital was S. aureus, present in daycare and emergency departments and Aer. hydrophila gr.1 among Gram-negative bacteria found in the surgical department. While in An-Najah National University Hospital (NNUH), the predominant Gram-positive bacteria were S. epidermidis and S. saprophyticus, present in departments of surgery and laboratories, respectively. At the same time, Pseudomonas luteola is among Gram-negative bacteria found in daycare departments. Also, the level of airborne microbial pollutants in Rafidia Governmental Surgical Hospital appeared in greater proportions than in NNUH, as it reached in Rafidia Governmental Surgical Hospital (12430.1188 CFU/m^3), while in NNUH (11779.3501 CFU/m^3). Besides, it was also found that the levels of microbial airborne in confined and crowded areas are much higher than in sparsely populated areas. Furthermore, the percentage increased in rooms with high temperatures and humidity. Finally, infection levels during the Corona pandemic are lower than in the pre-pandemic period. Conclusions: Environmental factors like crowding, temperature, and humidity affect airborne microbes' levels. As a result, it concluded that Rafidia Governmental Surgical Hospital is more polluted with microbial airborne; another reason could be due to the smallness of its facilities compared to NNUH. This study note the evidence and results that confirm our conclusion. As in comparing with previous studies, microbial pollution levels during the Corona pandemic were lower than in the pre-pandemic period, which means a commitment by the hospital's staff and patients to the public health and safety guidelines imposed by MOH, including the necessary sterilizations, wearing a mask and maintaining social distancing.

***Keywords*---**indoor air quality, hospital, Rafidia Governmental Surgical Hospital, microbial airborne.

Introduction

Indoor air quality has been the focus of scientists and specialists (Śmiełowska, Marć, and Zabiegała, 2017). It is important to us since we spend up to 90% of our time indoors (Sundell, 2004). Hospitals' Indoor air quality is an important issue for occupational and public health as it affects health, productivity and well-being (Bonetta, Bonetta, Mosso, Sampò, Carraro, 2010). The main role of the hospital is to provide full medical treatment, the most important of which is nursing care for patients. Many departments are represented in health care, such as operating theaters, intensive care units (ICUs), outpatient departments (OPDs), etc. (Leung & Chan 2006). Besides, it is one of the workplace environments that can be easily contaminated with various occupational risks, such as infectious materials or contaminated equipment, as well as blood and other body fluid from patients. Thus, healthcare staff is often susceptible to hospital environmental health hazards, including bioaerosol (Luksamijarulkul et al., 2019).

With the continuous development in the quality of life, researchers during the twenty-first century have put the breathing environment in the limelight.

Numerous studies contend that indoor air is more dangerous than outdoor air (Saini, Dutta, & Marques, 2020) because most individuals spend around 90% of their time indoors. Hence, the quality of the indoor environment has a significant impact on humans' well-being. Therefore, the scientific community has become increasingly worried about the impact of indoor air quality on health over the last two decades (Jones, 1999).

Indoor air quality is viewed as one of the most critical aspects that must be taken into consideration in hospitals. Consequently, it should be healthful to protect the patient, the patient's family, and healthcare workers from being exposed to infections (El-Sharkawy & Noweir, 2014). More precisely, there is a pressing need to protect patients at a higher risk of being affected by various airborne microbes more quickly than other patients, including immunocompromised patients (Leung & Chan, 2006).

Microbial air contamination can be bacterial or fungal, which is an indicator of healthy indoor quality (Božić & Ilić, 2019). The indoor air quality may be affected by the indoor bioaerosol contaminant that originates from the hospital equipment, machines, seats, and personal activities for healthcare workers and patients. Furthermore, smoking is considered one of the main causes of indoor air contamination, so all Health Care Facilities HCF must ban smoking and impose severe consequences for those who violate this rule. In addition, the outdoor quality in human breathing zones can be easily polluted by the outdoor contaminant that may come from different sources, such as mobile sources (cars, buses, etc.). This source may be due to the traffic that surrounds the hospital (El-Sharkawy & Noweir, 2014). Accordingly, Microbial contamination could be reduced by regulating human activities, ventilation rates, and filtration efficiency. However, a better understanding of the sources and reservoirs of airborne microorganisms is required for mitigation and prevention (Osman et al., 2018).

In 2015, a Taiwan study conducted by Jung about indoor air pollutants in hospitals and their association with different types of bacteria and fungi in 96 sites from 37 hospitals found that the fungal concentrations were higher at the hospitals with non-central air conditioning systems ($p < 0.05$) (Jung, Wu, Tseng, & Su, 2015). Verde conducted a study in a Portuguese hospital in the same year. The numbers of airborne bacteria and fungi were assessed by performing a bioaerosol quality survey at different locations in the hospital. Gram-positive cocci bacteria were dominant among the bacterial genera (88%): Staphylococcus (51%) and Micrococcus (37%). In comparison, the prevalent genera of fungus were Penicillium (41%) and Aspergillus (24%) (Verde et al., 2015).

In 2019, a study in South Korea mentioned that air transport is one of the main ways to spread several infectious diseases. Inadequate ventilation can facilitate the spread of viruses transmitted through infectious aerosols caused by patients coughing or sneezing - such as the coronavirus that causes Middle East Respiratory Syndrome (MERS) (Cho, Woo, & Kim, 2019). Another study in 2018 aimed to measure the concentrations of microorganisms (bacteria, fungi, and viruses) during two periods (winter and summer) in 7 rooms in two French hospitals. The results have shown that indoor air contains a complex combination of physical, chemical, and microbiological compounds (Baurès et al., 2018).

A study in 2016 was done in Rafidia Governmental Surgical Hospital to identify bacteria in the air of different sections of it. Results of this research showed that the total count of Gram-positive bacteria; coagulase-negative staphylococci (CoNS), and Micrococcus spp. were the most predominant among isolated bacteria from air samples in the neonatal room (N.R.), intensive care unit (ICU), and surgical operation rooms (SOR). (air sampling has ranged from 61.8%-100% and the average was 5158 CFU/m2 /h to 17753 CFU/m2 /h) (Adwan, Abedraboo, Adwan, & Al-Sheboul, 2016). Our study was unique because it was conducted during the Pandemic of Covid19 to determine the level of airborne bacterial and fungal pollutants that may affect hospital air quality. It also aimed to compare private and governmental healthcare institutions' indoor and outdoor air quality.

Method

Study Area and Site of Samples Analysis

Our study is an experimental cross-sectional study, whereas the hospital's (An-Najah National University Hospital (NNUH) and Rafidia Governmental Surgical Hospital) air samples were collected from five departments inside two hospitals: medical laboratories, emergency department, daycare unit, surgery department, and staff department. As well as two different outside of them, in a period extending between November and December of 2021. The collected samples were incubated, cultured, and identified in the microbiological laboratory, the Faculty of Medicine and Health Sciences, An-Najah National University, An-Najah National University, City of Nablus-Palestine.

An-Najah National University Hospital (NNUH) is a private, non-profit hospital that is Palestine's teaching hospital, providing both education and health services. It is also the first academic medical center hospital in Palestine to receive Joint Commission International accreditation (JCI). NNUH was established in 2013 in partnership with the Faculty of Medicine and Health Sciences (FMHS) at An-Najah National University. It is located in the northwestern mountainous area of Nablus, on the exit leading to Asira Ash-Shamaliya. And it has five main departments, with 135 beds and plans to expand to nearly 500. It also hosts the clinical research office that is attached to the medical education office at FMHS[1]. Rafidia Governmental Surgical Hospital is one of the fourteen Palestinian governmental hospitals operating in the West Bank, Followed by the Palestinian MOH, with a capacity of 200 beds and 628 employees. It was built in 1976, and it is one of the largest health institutions in the northern West Bank[2].

Air sampling

The samples were collected by the passive method, in which putting coded open Petri dishes containing Nutrient Agar (N.A.) that allow the growth of various types of bacteria and Sabouraud Dextrose Agar (SDA) that would enable the growth of

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[1] https://www.najah.edu/en/about/achievements-and-awards/an-najah-national-university-hospital-makes-history-as-first-academic-medical-center-in-palestine.

[2] https://en.wikipedia.org/wiki/Rafidia_Surgical_Hospital

fungi. The last one was modified with chloramphenicol -an antibiotic used to inhibit bacterial growth.

A single petri dish from each media was placed in different places of the selected departments and two outdoor sites at a high 1 m above the breathing zone. A duplicated sample was done during different periods, and the counts obtained were averaged. The time extends up to three hours for each time, the first sampling was from 11 to 2 Pm in November, and the second was from 9 to 12 Am during December. Some challenges while placing samples in the selected departments. Still, the authors successfully collected samples by helping officials and staff and in full compliance with public health and safety guidelines.

Microbiological procedure

After the exposure time, samples were taken to the laboratory (Faculty of Medicine and Health Sciences, An-Najah National University) and incubated at 37 °C for 24 h for bacteria and 25 °C for 3-5 d for fungi. The positive colonies were counted in both media (NA/SDA) After counting the colonies, CFU/m^3 were determined according to an equation called Omeliansky's formula (1940), which is:

$$N=5a \times 10^4 /(bt)$$

Where:
N is the microbial CFU/m3 of indoor air,
a is the number of colonies per Petri dish for the time t,
b is the Petri dish surface area (cm^2),
t is the exposure time (min).

Then, isolates were identified according to standard methods (Kootallur, Thangavelu & Mani, 2011). Sample codes were named according to the first letters of the hospital, department, and room, respectively. Example: Room No. 502 in Day Care Department (D.C.), An-Najah National University Hospital (N) → NDC502. See Table.1 shows the full name of the study codes.

Table.1 Full name of the study codes

Codes	Full Name
RS1	Surgical department room No.1
RS3	Surgical department room No.3
RSP	Staff department in Personnel room
RSS	Staff department in Secretarial room
RLBB	Laboratory in Blood Bank
RLR	Laboratory in Routine section
RDCP	Daycare unit in Patient room
RDCO	Daycare unit in Operations room
RER	Emergency in Reception
REP	Emergency in Patient room
ROED	Outdoor at the Emergency Door

ROMD	Outdoor at the Main Door
NS2427	Surgical department room No.2427
NS2411	Surgical department room No.2411
NSR	Staff department in Reception
NSG724	Staff department room No.G724
NL1108	Laboratory room No.1108
NL1117	Laboratory room No.1117
NDC502	Daycare unit room No.502
NDC510	Daycare unit room No.510
NER	Emergency in Reception
NEP	Emergency in Patient room
NOED	Outdoor at Emergency Door
NOCTW	Outdoor at Clinical Training Window

Environmental Condition Of Investigated Departments

Samples were collected on different days under both hospitals' environmental conditions. Various regulatory bodies in the USA suggest that indoor temperature should be maintained during winter months between 20°C and 24°C, while R.H. should be maintained between 20% and 60% (OSHA,2003). See Table.2 show the temperature and humidity of the targeted rooms in both hospitals, as well as the number of rooms and beds in each department.

Table 2 Environmental Conditions at Rafidia Governmental Surgical Hospital

Departments	Room Code	Temperature (°C)	Moisture (%)	# Rooms	# Beds
Surgical Dept.	RS1	1st → 18	1st → 70	7	14
		2nd →20	2nd → 50		
	RS3	1st → 21	1st →73		
		2nd → 25	2nd →55		
Staff Dept.	RSP	1st → 22	1st →73	7	-----
		2nd → 26	2nd →55		
	RSS	1st → 22	1st →73		
		2nd → 26	2nd →55		
Laboratory Dept.	RLBB	1st → 17	1st → 69	------	----
		2nd →20	2nd → 51		
	RLR	1st → 17	1st → 69		
		2nd →20	2nd → 71		
Day Care Dept.	RDCP	1st → 18	1st → 72	2	6
		2nd → 21	2nd → 50		
	RDCO	1st → 18	1st → 72		
		2nd → 21	2nd → 50		
Emergency Dept.	RER	1st → 21	1st → 75	12	26
		2nd → 27	2nd → 57		
	REP	1st → 21	1st → 75		
		2nd → 27	2nd → 57		

Outdoor	ROED	1st → 20	1st → 75		
		2nd → 26	2nd →55		
	ROMD	1st → 20	1st → 75		
		2nd → 26	2nd →55	------	-----

Table 3. Environmental Conditions at An-Najah National University Hospital

Departments	Room Code	Temperature (°C)	Moisture (%)	# Rooms	# Beds
Surgical Dept.	NS2427	1st → 25.8	1st → 32	20	23
		2nd → 26.9	2nd → 42		
	NS2411	1st → 24.9	1st → 34		
		2nd → 28.5	2nd → 46		
Staff Dept.	NSR	1st → 22	1st → 48	19	-----
		2nd → 25	2nd → 43		
	NSG724	1st → 24.8	1st → 48		
		2nd → 25	2nd → 43		
Laboratory Dept.	NL1108	1st →24.2	1st → 46	19	-----
		2nd → 28.2	2nd → 42		
	NL1117	1st → 25.8	1st → 29		
		2nd → 27.2	2nd → 31		
Day Care Dept.	NDC502	1st →24.5	1st → 50	12	14
		2nd → 26.6	2nd → 47		
	NDC510	1st → 21.5	1st → 50		
		2nd → 21.6	2nd → 47		
Emergency Dept.	NER	1st → 20.7	1st → 45	2	9
		2nd → 23	2nd → 25		
	NEP	1st → 20.7	1st → 45		
		2nd → 23	2nd → 25		
Outdoor	NOED	1st → 23	1st →73	------	-----
		2nd → 28	2nd → 56		
	NOCTW	1st → 23	1st →73		
		2nd → 28	2nd → 56		

Microbiological analysis and identification

To identify bacterial colony growth on N.A., the isolated colonies were cultured on blood agar (B.A.) and Macconkey agar (M.A.); to differentiate between the gram-negative and positive bacteria, then incubated at 37 C° for 24h. After the end of the incubation period, a suspension of bacteria with sterile normal saline was done on a slide for the microscopic examination to determine the morphology of the isolated bacteria, if it is cocci or bacilli. For gram-positive cocci bacteria, biochemical tests have been conducted. A catalase test was done to differentiate between the staphylococcus and streptococcus species. Then coagulase test was done for catalase-positive bacteria to distinguish between the staphylococcus species. Novobiocin sensitivity test was done for coagulase-negative bacteria to differentiate between S.saprophyticus and S.epidermidis.

Gram-positive bacilli bacteria were subcultured on B.A. and incubated at 37 C° for 24h. A smear of the obtained colony was prepared on a slide, air-dried, and heat-fixed. A spore stain with a malachite green stain was carried out on the prepared slide, filter paper was placed on the fixed smear, and while exposed to steam flood the smear and paper with stain for 10 min, decolourized the slide with water and stained it with safranin as a counterstain for 30 seconds. Then examined the slide under the microscope. For gram-negative bacteria that grew on M.A., the isolated bacteria were subcultured on B.A. and M.A. again and then incubated at 37 C° for 24h. After the incubation period, a suspension of bacteria was prepared with sterile normal saline and injected into the API tubes for incubation at 37 C° for 24h. Then the results were read according to the book designated for the API test, identifying the type of bacteria. Fungi that grew on SDA media were identified according to appearance and texture. Wet mount was prepared from the colony, examined under the light microscope to distinguish between molds and yeast, and compared with the Encyclopedia of Fungi**.**

Sample disposal and safety procedure

In order to preserve public health first and the environment secondly, the staff of the study used personal protective equipment (PPE) and samples containing bacteria and fungi were properly and safely destroyed in the Microbiology Laboratory located in the basement 1 floor of the Faculty of Medicine and Health Sciences at An-Najah National University.

Results

Airborne microbes were identified from five departments in the indoor air as well as two different sites in the outdoor air of the two hospitals by taking 96 samples. The results were presented in Tables 4 and 5.

Surgical Departments

Gram-negative bacteria were more prevalent than gram-positive bacteria in Rafidia Governmental Surgical Hospital. Air in the surgical departments was found to contain Aeromonas hydrophila grade 1 (2183.787561 CFU/m^3) as the predominant gram-negative bacteria, with Relatively few numbers of Acinetobacter baumannii (414.9196366 CFU/m^3). Among gram-positive bacteria, S. epidermidis (436.7575122 CFU/m^3) was the predominant one. The predominant isolated bacteria from the surgical department of NNUH was gram-positive bacteria. The air was rich in S. epidermidis (2856.394 CFU/m^3), while a small amount of Acinetobacter baumannii (537.21174 CFU/m^3) was founded as the gram-negative bacteria. Yeast was founded as the predominant in both hospitals (48.04333 CFU/m^3) in Rafidia Hospital and (26.20545 CFU/m^3) in NNUH.

Medical Laboratory

Medical laboratories of both Rafidia and NNUH were found to contain a greater number of gram-positive bacteria, only without gram-negative bacteria. Various species of staphylococcus were found in Rafidia Governmental Surgical Hospital, like S. aureus (240.2166317 CFU/m^3), S. epidermidis (305.7302586 CFU/m^3), and S.saprophyticus (69.8812 CFU/m^3) as gram-positive bacteria. Among these species, S.epidermidis was the predominant one, whereas the S. saprophyticus (2384.696017 CFU/m^3) was dominant in NNUH, and S. epidermidis (144.1299791 CFU/m^3) was also found in a small amount. Besides bacteria, yeast (21.83788 CFU/m^3) was found in Rafidia Governmental Surgical Hospital, while NNUH was found to be free from fungi.

Daycare Unites

Only S. aureus (2183.787561 CFU/m^3) and S. epidermidis (432.3899 CFU/m^3) were isolated from Rafidia Governmental Surgical Hospital as gram-positive bacteria, with the S. aureus as the predominant one. While in NNUH, Gram-negative bacteria were found in more prevalent numbers than gram-positive bacteria. Air was found to contain pseudomonas luteola (2183.787561 CFU/m^3) as the predominant gram-negative bacteria with Relatively few numbers of photobacterium damselae (257.6869322 CFU/m^3). Among gram-positive bacteria, S.epidermidis (489.1684 CFU/m^3) was the predominant one. Apart from bacteria, a small amount of yeast was found in both hospitals, with approximately the same percentage (8.73515 CFU/m^3).

Emergency Department

Different species of staphylococcus were found in the emergency department of Rafidia Governmental Surgical Hospital as Gram-positive bacteria, like S. aureus (2183.787561 CFU/m3), S. epidermidis (939.0287 CFU/m3), and S.saprophyticus (21.83787561 CFU/m3). Among these species, S.aureus was the predominant one, but it was found free from gram-negative bacteria. While in NNUH, Gram-positive bacteria were found in more prevalent numbers than gram-positive bacteria. Air was found to contain S.epidermidis (218.3788 CFU/m3) as the predominant gram-negative bacteria with Relatively few amounts of S.aureus (4.367575122 CFU/m3). Among gram-negative bacteria, Aci. baumannii (109.1893781 CFU/m3) was found as the predominant one. Yeast was found as the predominant fungi in both hospitals, with a greater percentage in Rafidia Hospital, where it's (34.9406 CFU/m3). In comparison, it's (21.83788 CFU/m3) in NNUH.

Staff Department

The gram-negative bacteria were found in a greater number than gram-positive bacteria in the staff department of Rafidia Governmental Surgical Hospital. The isolated gram-negative were Aci. Baumannii (519.7414396 CFU/m^3) was the prominent and Past. Pne/Mann. Haem (397.4493361 CFU/m^3). While the isolated gram-positive bacteria were S. saprophyticus (593.9902166 CFU/m^3) and S. aureus (244.5842068 CFU/m^3), the predominant one was S. saprophyticus. While in NNUH, only S.epidermidis (633.2984 CFU/m^3) was present as Gram-positive bacteria. Aerobic bacilli bacteria were also present in both hospitals, with a greater percentage in NNUH. Where it's (292.6275332 CFU/m^3). In comparison, it's (13.10272537 CFU/m^3) in Rafidia Governmental Surgical Hospital. Besides bacteria, yeast was found as the predominant fungi in both hospitals, in a greater percentage in Rafidia Hospital, where it's (21.83788 CFU/m^3). At the same time, it's (8.735150245 CFU/m^3) in NNUH.

Outdoor

The outdoor air in Rafidia Governmental Surgical Hospital was richer in gram-positive bacteria than gram-negative bacteria. Among the isolated gram-positive bacteria, S.epidermidis (537.21174 CFU/m3) and S. aureus (528.4765898 CFU/m3) were predominant in almost the same proportion. Among gram-negative bacteria, Serratia rubidaea (428.022362CFU/m^3) was only found. The outdoors of NNUH contained a greater number of gram-negative bacteria than gram-positive bacteria. Different types of gram-negative bacteria were found, like Aeromonas hydrophila grade 2 (397.4493361 CFU/m^3), Acinetobacter baumannii (803.633823 CFU/m^3), and vibrio fluvialis (21.83787561 CFU/m^3), among these types the predominant was Aci. baumannii. While the predominant gram-positive bacteria found was S. saprophyticus (314.4654088 CFU/m^3). Besides bacteria, yeast was also present in both hospitals, with a greater percentage in NNUH, where it was (65.5136268 CFU/m^3). In comparison, it's (56.7784766 CFU/m^3) in Rafidia Governmental Surgical Hospital. The results of Rafidia Governmental Surgical Hospital and NNUH are indicated in Tables 4 and 5, respectively.

Table 4. Average of bacterial and fungal CFU/m^3 air number during different times of exposure in Rafidia Governmental Surgical Hospital

Sampling Location	Room Number	Media used for sampling	Findings	Colony-forming units/plate	Total Microbial Load (CFU/m^3)	Level of contamination*
surgical department	1	N.A.	S. epidermidis	100	436.7575122	Intermediate
		SDA	Yeast	4	17.47030049	Low
	3	N.A.	Aer. hydrophila gr.1	>500	2183.787561	High
			Aci. baumannii	95	414.9196366	Intermediate
		SDA	Yeast	7	30.57302586	Low
medical laboratories	Routine section	N.A.	S. epidermidis	70	305.7302586	Intermediate
			S. saprophyticus	1	4.367575122	Low
		SDA	Yeast	3	13.10272537	Low
	Blood Bank	NA	S. aureus	55	240.2166317	Low
			S. saprophyticus	15	65.51362683	Low
		SDA	Yeast	2	8.735150245	Low
Daycare unit	operations room	N.A.	S. aureus	>500	2183.787561	High
			S. epidermidis	15	65.51362683	Low
		SDA	Yeast	1	4.367575122	Low
	Patient room	NA	S. epidermidis	84	366.8763103	Intermediate
		SDA	Yeast	1	4.367575122	Low
Staff department	Personnel room	NA	S. saprophyticus	136	593.9902166	High
			Past. Pne/Mann. haem	91	397.4493361	Intermediate
		SDA	Yeast	3	13.10272537	Low
	Executive Secretarial Room	NA	Aci. baumannii	119	519.7414396	High
			S. aureus	56	244.5842068	Low
			Bacilli	3	13.10272537	Low
		SDA	Yeast	2	8.735150245	Low
Emergency department	Reception	NA	S. epidermidis	179	781.7959469	High
		SDA	yeast	2	8.735150245	Low
	Patient room	NA	S. aureus	>500	2183.787561	High
			S. epidermidis	36	157.2327044	Low
			S. saprophyticus	5	21.83787561	Low
		SDA	yeast	6	26.20545073	Low
Outdoor	At the main door	N.A.	ser. rubidaea	98	428.022362	Intermediate
			S. epidermidis	40	174.7030049	Low
		SDA	yeast	2	8.735150245	Low
	At the emergency door	NA	S. aureus	121	528.4765898	High
			S. epidermidis	83	362.5087352	Intermediate
		SDA	yeast	11	48.04332635	Low

* The level of contamination was classified into three levels: <300 CFU/m^3 (Low), 300-500 CFU/m^3 (Intermediate), and >500 CFU/m^3 (High), according to Luksamijarulkul et al., 2019.

Table 5. Average of bacterial and fungal CFU/m^3 air number during different times of exposure in NNUH

Sampling Location	Room Number	Media used for sampling	Findings	Colony-forming units/plate	Total Microbial Load (CFU/ m^3)	Level of contamination*
surgical department	2427	NA	S. epidermidis	>500	2183.787561	High
		SDA	Yeast	1	4.367575122	Low
	2411	NA	S. epidermidis	154	672.6065688	High
			Aci. baumannii	123	537.21174	High
		SDA	Yeast	5	21.83787561	Low
medical laboratories	1108	NA	S. saprophyticus	>500	2183.787561	High
			S. epidermidis	7	30.57302586	Low
	1117	NA	S. saprophyticus	46	200.9084556	Low
			S. epidermidis	26	113.5569532	Low
Daycare unit	502	NA	Ps. Luteola	>500	2183.787561	High
			S. epidermidis	72	314.4654088	Intermediate
		SDA	Yeast	1	4.367575122	Low
	510	NA	photo. damselae	59	257.6869322	Low
			S. epidermidis	40	174.7030049	Low
		SDA	Yeast	1	4.367575122	Low
Staff department	Reception	NA	S. epidermidis	50	218.3787561	Low
			Bacilli	67	292.6275332	Low
		SDA	Yeast	2	8.735150245	Low
	G724	NA	S. epidermidis	95	414.9196366	Intermediate
Emergency department	Reception	NA	S. epidermidis	39	170.3354298	Low
			S. aureus	1	4.367575122	Low
		SDA	Yeast	2	8.735150245	Low
	Patient room	NA	Aci. baumannii	25	109.1893781	Low
			S. epidermidis	11	48.04332635	Low
		SDA	Yeast	3	13.10272537	Low
Outdoor	At the clinical training window	N.A.	Aer. hydrophila gr.2	91	397.4493361	Intermediate
			Aci. baumannii	30	131.0272537	Low
		SDA	Yeast	6	26.20545073	Low
	At the emergency door	NA	Aci. baumannii	154	672.6065688	High
			S. saprophyticus	72	314.4654088	Intermediate
			v. fluvialis	5	21.83787561	Low
		SDA	Yeast	9	39.3081761	Low

The level of contamination was classified into three levels: <300 CFU/m^3 (Low), 300-500 CFU/m^3 (Intermediate), and >500 CFU/m^3 (High), according to Luksamijarulkul et al., 2019.

Discussion

Indoor air quality is influenced by several factors, including the number of people present, the level of hygiene, the quality of the hospital system, and the mechanical movement within the confined space. At the same time, the quantity of bacteria in restricted places or spaces with a large number of employees, patients, and their families is substantially higher than in private locations for a limited number of employees or patients, such as private rooms for employees or a room with a small number of patients. Our study's findings support the Luksamijarulkul et al.(2019) conclusion. Rafidia Hospital, airborne microbes appeared in the following proportions: S. epidermidis (2651.1181 CFU/m^3), S. saprophyticus (685.7093 CFU/m^3), S. aureus (5380.853 CFU/M3), Aer. hydrophila gr.1 (2183.787561 CFU/m^3), Aci. baumannii (934.661076 CFU/m^3), Past. Pne/Mann. haem (397.4493361 CFU/m^3), ser. rubidaea(428.022362 CFU/m^3), bacilli (13.10273 CFU/^{3}), and yeast (192.1733 CFU/m^3). So, the predominant microbe was S. aureus. In NNUH, microbes appeared in the following proportions: S. epidermidis (4341.369671 CFU/m^3), S. saprophyticus (2699.161425 CFU/m^3), S. aureus (4.367575122 CFU/m^3), Aer. hydrophila gr.2 (397.4493361 CFU/m^3), Aci. baumannii (1450.034941 CFU/m^3), V. fluvialis (21.83787561 CFU/m^3), Ps. Luteola (2183.787561 CFU/m^3), photo. damselae (257.6869322CFU/m^3), bacilli (292.6275332 CFU/m^3), and yeast (131.0272537 CFU/m^3). So, the predominant microbe was S. epidermidis. The level of airborne microbial pollutants in Rafidia Governmental Surgical Hospital appeared in greater proportions than in NNUH, as it reached in Rafidia Governmental Surgical Hospital (12430.1188 CFU/m^3), while in NNUH (11779.3501 CFU/m^3). Good characterization of the sources that affect indoor air pollution levels is of major importance for quantifying and reducing) the associated health risks (Rivas et al., 2019). The IAQ can be improved by controlling the indoor sources of air pollution, such as floor coverings, air filters used in supply, and personal computers (Wyon, 2004). Furthermore, the growth rate of bacteria and fungi increased with the increase in humidity and temperature (Dannemiller, Weschler, & Peccia, 2017).

Outdoor air pollution may be due to traffic and combustion processes that penetrate the indoor air as well, especially in Rafidia Governmental Surgical Hospital, which is closer to traffic. Evidence indicates that Vehicle emissions, particularly automobile emissions, are responsible for almost two-thirds of air pollution in urban areas. The main automobile pollutants harm human health and the environment (Bhandarkar, 2013). This study, compared with Adwan, Abedraboo, Adwan, & Al-Sheboul, (2016) study, indicated that the Indoor air quality levels during the Corona pandemic were relatively high; As airborne microbes in the surgical department (the joint section with our study) were higher as documented in the study conducted in 2016.

Conclusions and Recommendation

Based on the comparison between the result of the two hospitals, it's viewed that Rafidia Governmental Surgical Hospital is the most contaminated with airborne bacteria and fungi; Because it is close to traffic congestion and the small size of its facilities compared to NNUH. As for the difference in the average levels of microbes before and during the Corona pandemic, we noticed a noticeable decline during the Pandemic in hospitals, especially in the essence of speech; there is an evident commitment by the hospital, staff, and patients to the public health and safety guidelines imposed by the MOH including the necessary sterilizations, wearing a mask, and maintaining social distancing. Both hospitals were informed of their results for consideration. All results were satisfactory, and we recommend that both hospitals maintain cleanliness and sterilization and adhere to public health and safety guidelines.

Abbreviations and definitions

IAQ: indoor air quality.
NNUH: An-Najah National University Hospital.

JCI: Joint Commission International.
FMHS: Faculty of Medicine and Health Science.
MOH: Ministry Of Health.
CFU: Colony Forming Unit.
ICUs: Intensive Care Units.
OPD's: Outpatient Departments.
CoNS: Coagulase-Negative Staphylococci.
N.R.: Neonatal Room.
SOR: Surgical Operation Room.
NA: Nutrient Agar.
SDA: Sabouraud Dextrose Agar.
B.A.: Blood Agar.
MA: Macconkey Agar.
API: Analytical Profile Index.
IRB: Institutional Review Board.

Declarations

Ethics approval and consent to participate

To carry out this study, all methods were carried out in accordance with relevant guidelines and regulations. Approvals from the Office of the Institutional Review Board (IRB) of An-Najah National University, MOH, NNUH, and Rafidia Governmental Surgical Hospital were provided. As this study was not conducted on humans, no consent to participate was obtained.

Consent for publication

'Not applicable'

Availability of data and materials

The datasets of the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Contributions

All authors listed have contributed to the work and approved it for publication. The authors have worked in an organized manner. W.M. has supervised the work, designed the study, communicated with the key persons, and edited and reviewed the final manuscript for approval. Other authors collected the data from the sites, conducted the diagnostic tests and wrote the manuscript. All authors reviewed and approved the final manuscript.

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