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Short Communication

Assessment of Airborne Fungal Contamination in Medical Cadet Dormitory Rooms at Phramongkutklao College of Medicine, Thailand

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Abstract

Indoor air quality (IAQ) is a critical determinant of health in residential and institutional settings. Airborne fungi are of particular concern due to their potential role in triggering allergies, respiratory symptoms, and opportunistic infections. This study aimed to assess the airborne fungal load and diversity in dormitory rooms at Phramongkutklao College of Medicine, Thailand. Air sampling was conducted in March 2025 in 40 dormitory rooms using the passive open-plate method with Sabouraud Dextrose Agar (SDA). Plates were exposed for one hour at approximately 1.0 m above the ground, incubated at 25°C for 7 days, and examined macroscopically and microscopically. Colony counts were expressed as colony-forming units per square meter per hour (CFU/m^2/h) and classified according to the Index of Microbial Air Contamination (IMA). Airborne fungal loads ranged from 157 to 17,296 CFU/m^2/h, with a median of 943 CFU/m^2/h (IQR 157-1,258), indicating that most rooms exhibited moderate levels, while a limited number showed markedly elevated counts. The predominant genera identified were *Aspergillus* spp., *Penicillium* spp. and *Mucor* spp. Overall, most rooms exhibited moderate to high contamination levels, with localized areas of very high fungal loads. These findings underscore the importance of routine environmental monitoring, ventilation management, and moisture control to sustain healthy living environments in medical dormitories. Future studies integrating active air sampling and molecular identification methods are recommended for a more comprehensive assessment.

Keywords: Colony-forming units per square meter per hour, Index of microbial air contamination, Indoor air quality, Passive open-plate method

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การประเมินการปนเปื้อนเชื้อราในอากาศภายในห้องพักนักศึกษาวิทยาลัยแพทยศาสตร์พระมงกุฎเกล้า ประเทศไทย

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บทคัดย่อ

คุณภาพอากาศภายในอาคาร (Indoor Air Quality; IAQ) เป็นปัจจัยสำคัญที่มีผลต่อสุขภาพของผู้อยู่อาศัย โดยเฉพาะเชื้อราที่แพร่กระจายในอากาศ ซึ่งอาจก่อให้เกิดอาการภูมิแพ้ โรคระบบทางเดินหายใจ และการติดเชื้อฉวยโอกาส งานวิจัยนี้มีวัตถุประสงค์เพื่อประเมินปริมาณและความหลากหลายของเชื้อราในอากาศภายในห้องพักนักศึกษาของวิทยาลัยแพทยศาสตร์พระมงกุฎเกล้า การเก็บตัวอย่างอากาศดำเนินการในเดือนมีนาคม พ.ศ. 2568 จากห้องพักนักศึกษาจำนวน 40 ห้อง โดยใช้วิธีเปิดเพลตแบบพาสซีฟ (passive open-plate method) บนอาหารเลี้ยงเชื้อ Sabouraud Dextrose Agar (SDA) จานเพาะเชื้อถูกเปิดทิ้งไว้ 1 ชั่วโมง ที่ระดับความสูงประมาณ 1 เมตรจากพื้น แล้วนำไปบ่มที่อุณหภูมิ 25°C เป็นเวลา 7 วัน จากนั้นตรวจสอบลักษณะโคโลนีด้วยการสังเกตทางตาเปล่าและกล้องจุลทรรศน์ จำนวนโคโลนีแสดงผลเป็นโคโลนีต่อพื้นที่ตารางเมตรต่อชั่วโมง (CFU/m^2/h) และจัดระดับตามดัชนีการปนเปื้อนจุลินทรีย์ในอากาศ (Index of Microbial Air Contamination; IMA) ปริมาณเชื้อราในอากาศมีการกระจายตัวไม่สม่ำเสมอ โดยมีค่าอยู่ในช่วง 157-17,296 CFU/m^2/h ค่ากลางของข้อมูลเท่ากับ 943 CFU/m^2/h (IQR 157-1,258) ซึ่งสะท้อนว่าห้องส่วนใหญ่อยู่ในระดับปานกลางถึงสูง ขณะที่มีเพียงบางห้องที่มีค่าการปนเปื้อนสูงมาก เชื้อราสำคัญที่ตรวจพบ ได้แก่ *Aspergillus* spp., *Penicillium* spp. และ *Mucor* spp. โดยสรุปพบว่าโดยรวมอยู่ในระดับปานกลางถึงสูง และพบเพียงบางห้องที่มีการปนเปื้อนสูงมาก ผลการศึกษาชี้ให้เห็นถึงความสำคัญของการเฝ้าระวังสิ่งแวดล้อม การจัดการระบบระบายอากาศ และการควบคุมความชื้น เพื่อรักษาสภาพแวดล้อมที่ปลอดภัยและส่งเสริมสุขภาพของนักศึกษา แนะนำให้มีการศึกษาต่อเนื่องโดยใช้วิธีเก็บตัวอย่างอากาศแบบแอคทีฟ และการระบุชนิดเชื้อราด้วยเทคนิคทางชีวโมเลกุล เพื่อเพิ่มความครอบคลุมและความแม่นยำของข้อมูล

คำสำคัญ: โคโลนีต่อพื้นที่ตารางเมตรต่อชั่วโมง ดัชนีการปนเปื้อนจุลินทรีย์ในอากาศ คุณภาพอากาศภายในอาคาร วิธีการเปิดเพลตแบบพาสซีฟ

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1. Introduction

Indoor air quality (IAQ) is a critical determinant of human health, particularly in residential and institutional settings where individuals spend a significant portion of their time. Among various indoor pollutants, airborne fungi are of particular concern due to their potential to cause allergic reactions, respiratory issues and opportunistic infections, especially among immunocompromised individuals.[1-2] The proliferation of these microorganisms is influenced by environmental factors such as humidity, temperature, ventilation, and human activities.[3-4]

Dormitory environments, characterized by high occupant density and shared facilities, present unique challenges for IAQ management. Studies have shown that such settings can harbor elevated levels of airborne fungi including genera like *Aspergillus* spp., *Penicillium* spp. and *Mucor* spp. Which are commonly associated with indoor environments.[5-6]

In Thailand, several studies have investigated the presence of airborne fungi in various indoor settings. Thunyaharn *et al*. identified *Cladosporium* spp. and *Aspergillus* spp. as dominant genera in buildings of Nakhon Ratchasima College, with fungal concentrations correlating with occupancy levels.[5] Another study in a Bangkok nursing dormitory found high counts of *Aspergillus* spp., especially on lower floors due to inadequate air circulation.[6] In post-disaster environments, such as after the 2016 flood in Thailand, mold proliferation was significantly associated with poor indoor air quality and increased health risks.[7] A recent investigation of ancient stone temples in Surin also reported *Aspergillus* spp. As a dominant airborne fungal contaminant, indicating its widespread presence even in historical and religious structures.[8] Even in non-disaster settings, studies have found considerable levels of airborne fungal spores in university dormitories and libraries, indicating the need for regular monitoring.[5-6,9-11]

Environmental factors such as relative humidity (RH), temperature and building height have been shown to significantly influence indoor fungal concentrations. A study in Nakhon Si Thammarat, Thailand demonstrated that increased RH and building height were positively associated with higher fungal loads, while temperature exhibited a negative correlation.[9] These findings emphasized the importance of environmental controls in managing IAQ.

Phramongkutklao College of Medicine (PCM) is the only medical school in Thailand affiliated with the Royal Thai Army. Each year, it produces approximately 100 medical cadet graduates who serve in military healthcare settings across the country. During their second and third academic years, medical cadets reside in a dormitory building within the college campus. These accommodations are in buildings that are more than 50 years old and there has been no academic research on this issue. Therefore, regular monitoring and preventive measures are essential to maintain a safe, healthy, and conducive environment for the residents' academic and personal well-being.

Assessment indoor airborne fungi is commonly conducted using passive methods like the open-plate (settle plate) technique, which is practical for routine monitoring despite its limitations in quantifying low-concentration spores compared with active air samplers.[12] Culture-based methods, combined with morphologic and microscopic identification, remain widely used due to their accessibility in low resource settings.[13]

Given the unique military affiliation of PCM and the critical need for healthy living environments for medical cadets, this study aimed to evaluate airborne fungal contamination in its dormitory facilities. Findings from this research will support evidence-based strategies to maintain air hygiene, reduce health risks and promote optimal indoor environmental quality in military-affiliated academic institutions.

2. Materials and Methods

2.1 Sampling

The study was conducted at Phramongkutklao College of Medicine, Bangkok, Thailand. Forty rooms within a dormitory building room were selected by convenience sampling based on accessibility and occupancy status at the time of sampling in March 2025. Room dimensions: 3m (W) × 5m (L) × 3m (H). Fungal aerosols were collected using the open-plate method. In each room, a sterile 90-mm petri dish (two plates per room were placed as same time and position) containing SDA (Difco™ & BBL™ / USA) was opened and exposed to the air for 1 hour at approximately 1.0 meter above the ground level, positioned under the airflow area of an air conditioner. On a typical March afternoon in Bangkok, temperature ranges from 28-30°C with relative humidity around 60-75%. Doors and windows were kept closed during sampling to minimize environmental variation.

2.2 Cultivation

After exposure for 1 hour, the plates were immediately closed, labeled and transferred to the laboratory. Plates were incubated at 25°C for 7 days, with colony growth examined and recorded once daily during the entire incubation period.

2.3 Identification

Fungal colonies were initially examined based on macroscopic morphology (colony color, texture and growth pattern). For microscopic identification, colonies were stained using lactophenol cotton blue (Himedia™ / India) by teasing mount technique and observed under a light microscope to examine conidia structures and hyphal characteristics. Identification was based on morphologic characteristics and classified at the genus level using a fungal morphological key 'Descriptions of medical fungi' of Kidd *et al*. (2016).[14]

2.4 Analysis

The number of colonies on each plate was manually counted after 7 days of incubation. Colony counts were converted to colony-forming units per square meter per hour (CFU/m^2/h) using this formula.[15-16]

$$CFU/m^2/h = N/Axt$$

N is the number of colonies counted on the plate, A is the surface area of the Petri dish (0.00636 m^2 for a 90-mm plate), and t is the exposure time in one hour. The calculated values were compared with the Index of Microbial Air Contamination (IMA) standards to classify contamination level as very low contamination, low contamination, moderate contamination, high contamination, and very high contamination (Table 1).[15-16]

Table 1 The index of microbial air contamination (IMA).

IMA class	Contamination level	CFU/m²/h
IMA 1	Very low contamination	≤ 25
IMA 2	Low contamination	26-100
IMA 3	Moderate contamination	101-500
IMA 4	High contamination	501-2,000
IMA 5	Very high contamination	> 2,000

3. Results

3.1 Fungal colony growth and identification

The sampling and cultivation of airborne fungi from the dormitory rooms at Phramongkutklao College of Medicine revealed a wide range of fungal loads (157-17,296 CFU/m^2/h), with most rooms falling within moderate to high contamination categories. After incubating at 25°C for 7 days, colony growth was observed on SDA plates. Fungal colonies were predominantly small, with slow growth and limited sporulation. The representative colony morphology of the fungal isolates was illustrated in Fig. 1. Microscopic examination using lactophenol cotton blue staining identified the main genera as *Aspergillus* spp., *Penicillium* spp. and *Mucor* spp. (Fig. 2).

3.2 Indoor air quality evaluation

Airborne fungal loads in the 40 dormitory rooms ranged from 157 to 17,296 CFU/m^2/h (Table 2). The overall median fungal load was 943 CFU/m²/h (IQR 157-1,258), while the mean ± SD was 1,529 ± 2,935 CFU/m^2/h, reflecting a right-skewed distribution caused by several rooms with markedly elevated values.

According to the Index of Microbial Air Contamination (IMA), rooms were classified as follows: moderate contamination (101-500 CFU/m^2/h), high contamination (501-2,000 CFU/m^2/h), and very high contamination (>2,000 CFU/m^2/h). Most rooms were within the moderate to high contamination categories, while a small number were classified as very high contamination.

Markedly elevated fungal loads were observed in a limited number of rooms, including 210B (3,931 CFU/m²/h), 214B (7,862 CFU/m²/h), 603B (17,296 CFU/m²/h), and 606A (4,717 CFU/m²/h), which contributed substantially to the overall variability. Overall, most dormitory rooms exhibited moderate to high fungal levels, with a limited number of rooms requiring targeted environmental monitoring and remediation.

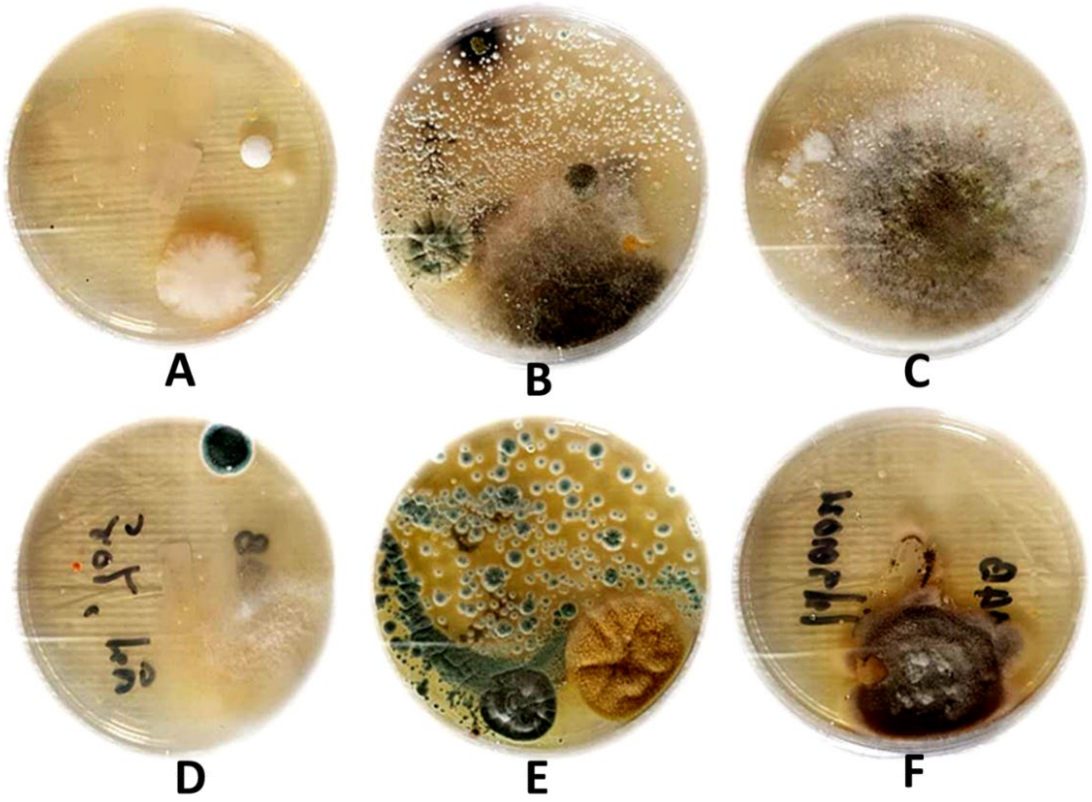


Fig. 1 (A-F) Representative fungal colonies grown on Sabouraud Dextrose Agar (SDA) after incubation at 25°C for 7 days. Overall colony morphologies included cream-colored glabrous, white cottony, white powdery, and green velvety textures. (1A) A large white cottony filamentous fungal colony with diffuse margins accompanied by a small smooth circular colony, possibly yeast-like. (1B) Numerous small creamy colonies consistent with bacteria or yeasts, together with dark green to black filamentous fungal colonies showing fuzzy texture. (1C) A dominant dark grey to black filamentous fungal colony with dense powdery to velvety surface and radial growth, characteristic of sporulating molds. (1D) A small dark green circular mold colony with well-defined margins. (1E) Dense distribution of small smooth colonies consistent with bacteria or yeasts, along with multiple filamentous fungal colonies of varying colors and textures. (1F) A dominant dark brown to black filamentous fungal colony with thick, fuzzy appearance, suggestive of a mature mold.

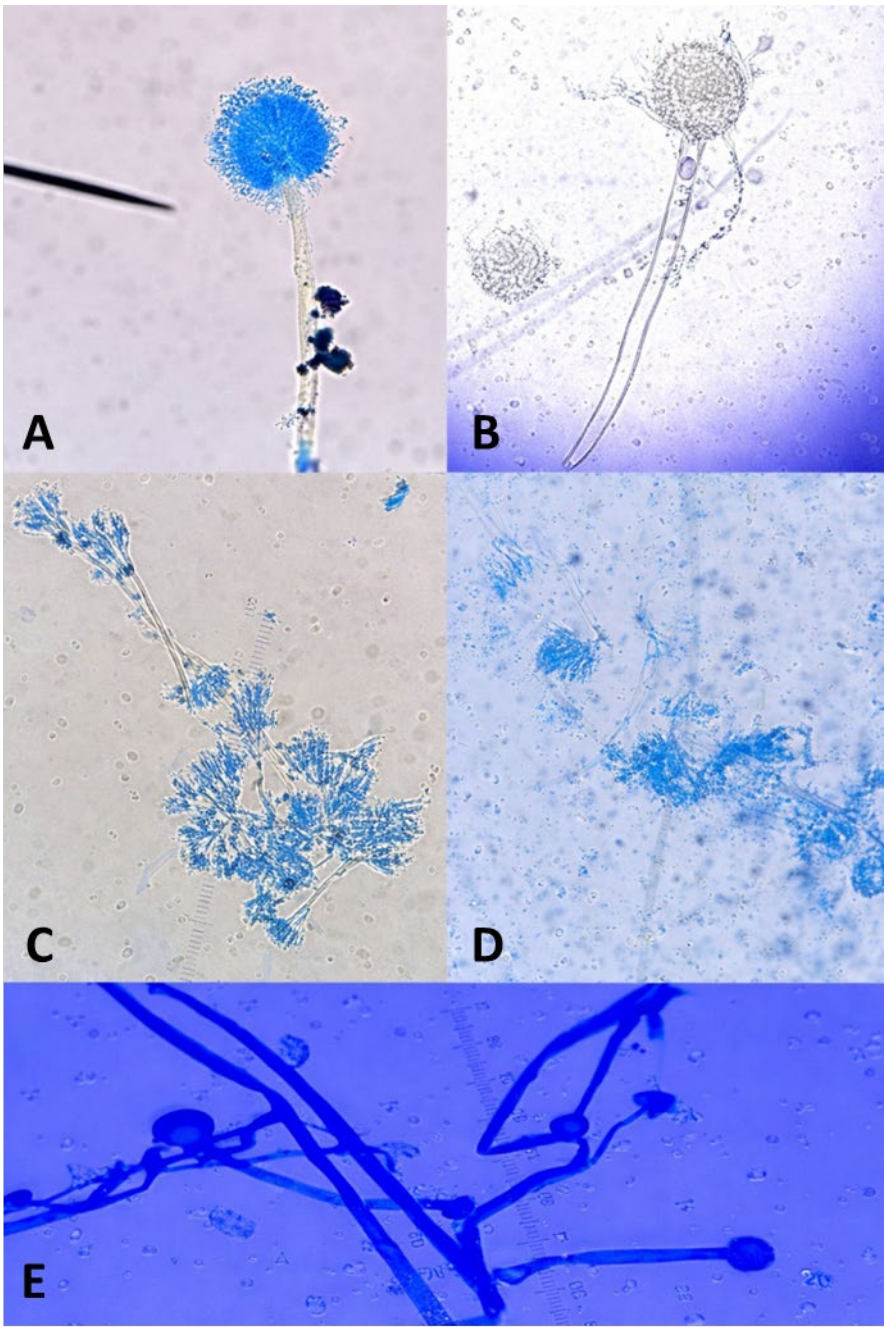


Fig. 2 Microscopic morphology of molds observed at 40X magnification after lactophenol cotton blue staining. *Aspergillus* spp. (A, B) showed small spherical to sub-spherical conidia produced in long chains from phialides arranged uniseriately or biseriately on a swollen vesicle at the tip of the conidiophore. *Penicillium* spp. (C, D) exhibited round to elliptical conidia formed in chains from phialides arranged in a characteristic brush-like (penicillus) structure, with branched conidiophores forming metulae and phialides. *Mucor* spp. (E) lacked conidia and reproduced asexually by producing round to oval sporangiospores enclosed within a spherical sporangium at the tip of a broad, non-septate sporangiophore, which are released upon sporangial rupture.

Table 2 Fungal colony morphology, quantity of fungi (CFU/plate), quantity of fungi (CFU/m^2/h) and Indoor Air Quality Classification (IMA) in dormitory rooms.

Room	Colony morphology		Quantity of fungi (CFU/plate)	Quantity of fungi (CFU/m^2/h)	IMA class*
	Color	Texture			
203A	Cream	Glabrous	6	943	
203B	Cream / White	Glabrous / Cottony	7	1101	
204B	White, Brown / Cream	Powdery / Glabrous	8	1258	
205A	White	Powdery	1	157	
205B	White, Brown, Black	Fluffy	2	314	
206A	White / Cream	Powdery / Glabrous	9	1415	
206B	White / Cream	Powdery / Glabrous	10	1572	
207A	White	Velvet	8	1258	
207B	White, Black	Cottony	1	157	
208B	White, Black	Cottony	1	157	
209A	White	Powdery	1	157	
209B	White / Cream	Powdery, Velvet / Glabrous	6	943	
210A	White / Cream, Yellow	Cottony / Glabrous	7	1101	
210B	White, Black	Powdery	25	3931	
211A	White / Cream / Green	Cottony / Glabrous / Velvet	8	1258	
211B	White / Cream	Cottony / Glabrous	7	1101	
212A	Cream / Black / Cream	Glabrous / Velvet / Glabrous	6	943	
212B	White	Cottony	10	1572	
213A	White / White	Velvet / Cottony	1	157	
213B	Cream, Yellow, Orange / White, Green / White	Glabrous / Powdery / Cottony	9	1415	
214A	Cream / Green	Glabrous / Velvet	8	1258	
214B	Yellow / White	Powdery / Cottony	50	7862	
215A	White	Cottony	7	1101	
215B	Black / White, Black	Velvet / Cottony	1	157	
216A	White	Cottony	1	157	
216B	Black, Brown / Cream	Velvet / Glabrous	1	157	
601A	White	Powdery	6	943	
601B	Cream, Yellow / Green / White	Glabrous / Velvet / Cottony	6	943	
602A	Cream / White / White	Glabrous / Powdery / Velvet	7	1101	
602B	Cream / White	Glabrous / Powdery	10	1572	
603A	White, black	Cottony	1	157	
603B	White, Green / Cream	Velvet / Glabrous	110	17296	
604A	Cream	Glabrous	6	943	
604B	Black / White, Green	Velvet / Cottony	7	1101	
605A	White	Powdery	1	157	
605B	Black / White	Velvet / Cottony	1	157	
606A	Cream / White	Glabrous / Fluffy	30	4717	
606B	Black	Velvet	1	157	
607A	White	Cottony	1	157	
607B	Green	Velvet	1	157	

*Remark

= Very low contamination (≤ 25 CFU/m^2/h)
= Low contamination (26-100 CFU/m^2/h)
= Moderate contamination (101-500 CFU/m^2/h)
= High contamination (501-2000 CFU/m^2/h)
= Very high contamination (>2000 CFU/m^2/h)

4. Discussion

This study assessed the airborne fungal load in dormitory rooms at Phramongkutklao College of Medicine (PCM), providing new evidence on indoor air quality (IAQ) in a military-affiliated medical school setting. The present study demonstrated a wide variation in airborne fungal loads, ranging from 157 to 17,296 CFU/m^2/h. The median value of 943 CFU/m^2/h (IQR 157-1,258) suggests that most dormitory rooms exhibited moderate to high fungal levels, whereas only a limited number showed very high contamination.

The predominant fungal genera identified in this study, namely *Aspergillus* spp., *Penicillium* spp., and *Mucor* spp. are consistent with previous reports from student dormitories and educational buildings in Thailand and other countries. Similar fungal profiles have been reported in dormitory environments, although the absolute fungal loads varied depending on sampling methods, season, and environmental conditions. The relatively wide range of fungal concentrations observed in the present study may reflect differences in room location, ventilation patterns, and moisture-related factors, as previously suggested by other investigators.[15,17-18]

The fungal genera identified—*Aspergillus* spp., *Penicillium* spp. and *Mucor* spp. are commonly reported in indoor air studies and are consistent with findings from previous investigations in dormitories, schools, and healthcare-associated environments.[15,17] *Aspergillus* spp. and *Penicillium* spp. are ubiquitous molds known for their ability to disperse conidia easily, while *Mucor* spp. typically produces sporangiospores that can accumulate in enclosed or moisture-prone environments. Although these fungi are widely present in the environment, elevated concentrations may contribute to allergic symptoms or opportunistic infections in susceptible individuals, highlighting the importance of maintaining adequate IAQ in student housing.

The presence of rooms with higher fungal loads (classified as Very Poor) may be attributable to localized environmental or structural factors, such as limited natural ventilation, moisture accumulation, or occupant activities. These findings emphasize the importance of targeted interventions, including improved ventilation practices, humidity control, and routine environmental monitoring, to reduce the potential risk of fungal proliferation in selected areas. Importantly, the detection of outliers should not be interpreted as a general characteristic of the dormitory environment, as the majority of rooms remained within acceptable ranges.

This study has several limitations. First, passive open-plate sampling, while practical and widely used, is less sensitive than active air samplers and may underestimate airborne fungal counts. Second, fungal identification was restricted to genus level using morphological criteria; molecular techniques would provide more precise species-level identification, particularly for pathogenic or toxigenic fungi. Third, environmental parameters such as temperature and relative humidity were not recorded, although these factors are known to influence fungal growth and spore dispersal. Future studies should systematically collect data on room location (e.g., floor level, corner vs. central rooms, orientation, and proximity to moisture sources), as well as environmental variables during sampling (including temperature, relative humidity, CO_2 concentration, ventilation conditions, room usage, and air-conditioning maintenance). Such comprehensive data would enable robust statistical analyses and facilitate clearer interpretation of environmental risk factors associated with airborne fungal contamination.

5. Conclusions

The majority of dormitory rooms at PCM demonstrated moderate to high levels in most rooms, with a small subset showing very high contamination. Only a small subset of rooms exhibited markedly elevated fungal counts, underscoring the importance of routine surveillance and localized interventions rather than

institution-wide concerns. These findings provide a useful baseline for future IAQ monitoring in medical student housing and support the implementation of preventive strategies to promote safe and healthy living environments.

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