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Effect of Workplace Environment on Treatment Response among Employees with Fungal Infections: A Comparative Study of Air-Conditioned and Non-Air-Conditioned Settings

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Abstract

Background: *Fungal skin infections are a major occupational health concern, especially in warm, tropical regions. The physical workplace environment such as indoor temperature and humidity, may heavily influence how well a patient recover. This study compared how well employees with fungal infections responded to treatment in air-conditioned (AC) versus non-air-conditioned (non-AC) workplace settings.*

Methodology: *A Descriptive study was conducted among 100 clinically diagnosed employees at the Pan Pacific Sonargaon Hotel. Participants were divided equally into two groups: those working in AC environments (n = 50) and those in non-AC environments (n = 50). All participants received standard local and systemic antifungal therapy. Treatment responses were tracked and categorized as complete cure, partial cure, or non-response.*

Results: *Majority of participants were males and aged between 31–40 years in both groups. A highly significant difference was observed in healing between the two groups ($p < 0.001$). In AC group, 88% of employees achieved a complete cure, 10% had a partial cure, and only 2% did not respond with the treatment. On the other hand, in non-AC group, only 26% achieved a complete cure, while 56% showed a partial cure and 18% had no response at all. Non-AC workers also displayed more severe skin lesions and higher rates of co-morbidities like diabetes.*

Conclusion: *The workplace environment specially with the use of air conditioner (AC), heavily influences the recovery from fungal infections. The cooler and low-humidity AC settings are more effective in healing rates than non-AC spaces. Better workplace settings, like better ventilation and humidity control, are essential for better treatment outcome in fungal infections.*

Keywords: *Fungal infections, Workplace environment, Air-conditioning, Skin lesions, Occupational health*

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I. Introduction

Rapid urbanization and increasing digitalization have substantially transformed modern lifestyles from open-air environments to enclosed, machine-dependent settings in both homes and workplaces.(1,2) People now spend majority of their time in this machine controlled indoor environment rather than natural ventilation through windows and doors. This controlled indoor environment condition mostly regulated with the latest Heating, Ventilation, and Air Conditioning (HVAC) systems. An air-conditioned indoor environment can be both beneficial and harmful to human health, as they control environmental conditions that can either reduce the survival of infectious agents or create favorable conditions for the persistence and transmission of airborne infections.(3)

Fungal infection has become a major concern among working people which mostly grows in warm, humid and stagnant conditions. With presence of elevated temperature and humidity, the tropical and subtropical regions are mostly favorable to fungal proliferation. The most common fungal diseases are dermatophytosis, candidiasis, and aspergillus which affect significantly among working populations.(4) Majority of these fungus effect on the skin superficially, however, when fungal spores becomes airborne, this may also contribute to the

respiratory system, allergic reactions and sick building syndrome. Beyond their clinical consequences, fungal infections enforce a considerable economic burden on the people. It may cause absent at work, decreased workplace productivity, and increased healthcare expenditures while treating the fungal infection. These impacts underscore the importance of understanding environmental determinants that may influence treatment response and recovery from common fungal infections among working populations.(5) The workplace environmental conditions play a crucial role in both the acquisition of this infection and treatment outcomes.(6)

The features of indoor workplace environments significantly affect fungal transmission, perseverance, and exposure. Although air-conditioned workplaces are designed to provide thermal comfort and improved work efficiency, it may create environments favorable to fungal survival and spreading through circulated air, contaminated ducts, and scant humidity regulation.(7) Many studies identified several fungal spores in the air-conditioning systems such as *Aspergillus*, *Penicillium*, and dermatophyte species.(7–9) According to an online survey of Japanese population, among 1006 participants, 37.1% reported moldy odor in household ACs, which indicates presence of fungus in the circulation.(10) On the other hand, in non-air-conditioned workplace environments, direct sunlight, fluctuating humidity, and natural ventilation may influence fungal growth and persistence diseases, especially on the skin. Such local climatic conditions usually affect fungal germination and structural expansion, which mostly effect on the human skin barrier, disease progression and treatment outcomes.(11) Employees working in environments with high fungal burden may experience delayed healing, treatment failure, or recurrent infections despite appropriate pharmacological intervention.(12) This environmental difference raises an important clinical question regarding the efficacy of standard antifungal therapies. Working in high-temperature settings also cause excessive sweating which may dilute the topically applied antifungal medications resulting in delayed healing process. An employee undergoing treatment in a non-air-conditioned setting experiences a continuous physiological challenge due to heat and humidity, conversely, an employee in an air-conditioned setting might benefit from a cooler and clear air circulation at different settings.(13)

There are several known environmental factors related with fungal infection, however, the knowledge regarding effect of air-conditioning on treatment response across different workplace settings remain scarce. Most research focuses on the prevalence of fungal infection prevalence or effect of environment over fungal infection alone without actually assessing the treatment outcomes on different environmental surroundings. This gap is particularly significant in developing countries like Bangladesh, where tropical climate conditions favor fungal growth. Therefore, this study aimed to assess the relationship of air-conditioned environment and treatment response among employees with fungal infections. The findings will contribute to create evidence-based workplace health policies and improve clinical management of occupational fungal diseases.

II. Method

Study Design and Setting: This Descriptive study was conducted to evaluate the effect of workplace environmental conditions with air conditioner (AC) use on treatment response among employees of Pan Pacific Sonargaon Hotel, diagnosed with fungal infections. Participants were recruited of two distinct occupational settings: air-conditioned (AC) and non-air-conditioned (non-AC) workplaces. The study aimed to assess the differences in clinical outcomes following standard antifungal therapy between two groups.

Study Population and Sampling: About 100 clinically diagnosed cases of fungal infections were included in the study. Sample size was calculated with 95% confidence interval, 5% marginal error and unknown prevalence of fungal infection. About 50 participants were recruited from non-AC working environment and 50 participants were from AC settings environment. These participants were selected using purposive sampling technique based on inclusion criteria. Individuals with confirmed fungal skin infections and who were undergoing treatment during the study period were eligible for inclusion. Patients with severe systemic illness or incomplete clinical records were excluded.

Data Collection: Data were collected using a semi-structured questionnaire and clinical record review. The questionnaire had included socio-demographic variables (age, sex, residence), occupational environment (AC vs non-AC), and history of comorbid conditions including diabetes mellitus, hypertension, ischemic heart disease, COPD, and cerebrovascular disease. The questionnaire also recorded information regarding presenting symptoms, family history of similar skin disease, and current treatment status. The treatment response was considered based on level of clinical improvement and the outcome was categorized as: complete cure, partial cure, and non-response to treatment. Assessment of outcome was finalized following completion of the prescribed antifungal therapy period. All these data were collected in the questionnaire and after completion, data were coded for final analysis.

Data Analysis: Data were analyzed using descriptive statistics to summarize baseline characteristics. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation. Comparative analysis between AC and non-AC groups was performed, and statistical

significance of differences in treatment response was determined using Chi-square test. A p-value of <0.05 was considered statistically significant.

Ethical Consideration: Ethical approval was obtained from the relevant institutional review body. Informed consent was obtained from all participants prior to data collection, and confidentiality of patient information was strictly maintained throughout the study.

III. Result

A total of 100 hotel employees diagnosed with cutaneous fungal infections were included in the study to evaluate the effect of workplace environment on therapeutic outcomes. The participants were equally recruited from air-conditioned (AC) workplace settings (n = 50) and non-air-conditioned (non-AC) environments (n = 50). Baseline sociodemographic and clinical characteristics, along with treatment outcomes, were compared between the two groups to assess the influence of workplace environmental conditions on the recovery and treatment response of fungal infections among the participants.

Among the study participants, the 31–40 years' age group constituted the largest proportion in both workplace environments. Whereas, the older employees of 51–60 years' age represented the smallest proportion across both groups **Figure-1.**

The mean age of participants was 38.04±10.09 years among the AC environment and those in the non-AC environment having a mean age of 39.42±10.01 years. Male participants predominated in both workplace settings, 70.0% in the AC environment and 56.0% in the non-AC environment. The majority of participants in both groups were from rural areas (78.0% in AC and 72.0% in non-AC settings). Regarding co-morbidities, diabetes mellitus (36.0%) and hypertension (34.0%) were more frequent among employees in non-AC environments, whereas ischemic heart disease (22.0%) and COPD (10.0%) were relatively higher among employees in AC environments (**Table-1**).

About 53% participants of AC environment and 47% participants of non-AC environment reported having family members affected with similar skin diseases, while the remaining participants reported no such family history in both groups (**Figure-2**).

Clinical symptoms varied across workplace environments. Skin lesions (36.0%) and infected focus (22.0%) were more frequently observed among employees in non-AC settings compared to AC settings (10.0% and 8.0%, respectively). Circular rash was more common among employees in AC environments (90.0% vs. 70.0%), while itching was reported by all participants (100%) in both groups. Nearly all participants in both workplace settings received combined local and syst emic treatment (100% in AC and 98.0% in non-AC environments) (**Table-2**).

Treatment response by workplace environment

A statistically significant difference in treatment response was observed between workplace environments ($p < 0.001$). The majority of employees in AC environments achieved complete cure (88.0%), whereas partial cure (56.0%) and non-response to treatment (18.0%) were more frequent among employees in non-AC environments **(Table-3)**.

IV. Discussion

This study reveals a significant association between use of air conditioner at working place and treatment response among employees with fungal infections. A higher rate of complete cure was observed among employees working in air-conditioned environments compared to those in non-air-conditioned settings. This finding suggests that the workplace environment may play an important role in influencing therapeutic outcomes in cutaneous fungal infections.

The observed differences are largely influenced by differences in temperature, humidity, and ventilation between the two settings. Air-conditioned environments typically maintain lower humidity and more controlled temperatures, which are less favorable for fungal proliferation and reinfection. In contrast, non-air-conditioned workplaces often have higher humidity and heat, conditions known to promote fungal survival and persistence. This finding was similar with conclusions by Ilies et al. (2025), who noted that high indoor humidity levels and elevated temperatures significantly accelerate the structural expansion and germination of superficial fungi on the human skin barrier.(14) The environmental effect creates a continuous physiological challenge, leading to delayed clinical improvement despite appropriate therapy.(12) However, there are potential risks of AC settings, where poorly maintained HVAC systems can act as favorable place for concentrating and recirculating opportunistic fungus such as *Aspergillus* and *Penicillium* directly.(10,13)

The demographic profile of our participants showed that majority individuals were aged 31–40 years in both groups. The male was predominant in both groups. Similar findings were seen in many studies where young male predominance were found as working class population.(15) The study also found that there was relatively higher burden of comorbidities such as diabetes mellitus and hypertension in the non-AC group. Diabetes is a well-established risk factor for both increased susceptibilities to fungal pathogens and delayed treatment response.

This occurs because chronic hyperglycemia impairs innate immune defenses of neutrophil and macrophage functions, while causing reduce tissue perfusion and slow cutaneous healing.(16)

Clinical presentations were also different between the two groups, where non-AC environments had showed higher proportions of skin lesions and multiple infected foci, suggesting potentially more severe or extensive disease. On the contrary, circular lesions (typical of tinea infections) were more commonly witnessed in patients with AC environments. However, both the AC and non-AC group had itching as presenting symptom in our study which is a common feature in fungal infection and can be present with this infection irrespective of environment. This finding is supported by the other studies which highlighted that the that symptom severity may be aggravated by both cool, dry air-conditioned environments and warm, humid non-air-conditioned settings.(17,18) The presence of similar skin infections among family members suggests possible household transmission or shared domestic exposure in both groups. This finding that fungal infections can be highly contagious and alarming. Similarly, Jenks et al. (2023) reported that overcrowded household environments and constrained workplace settings play a significant role in stimulating fungal persistence and increasing relapse rates.(4)

In our study all participants received a combination of local and systemic treatment in both groups. Our study found that there was a strong statistical relation between the workplace environment and treatment response ($p < 0.001$). This finding showed that there was a relationship of environment on the therapeutic treatment of cutaneous fungal infection. This variation in outcomes indicates that pharmacotherapy alone may not be effective without controlling the surrounding environment. These findings highlight the importance of workplace environmental modifications such as structural improvements in ventilation, localized humidity control, and regular climate maintenance in non-AC settings. These efforts may enhance treatment effectiveness and significantly reduce recurrence rates of many fungal infections.

However, there are several limitations in this study. The descriptive study design limits the ability to detect any causal implications. There are potential confounding factors, such as the exact duration of the baseline infection, individual compliance to topical regimens, and occupational exposure intensity, were not fully controlled. Also, there were not enough information regarding the specific treatment, its duration, or maintenance of individual participants. Despite these limitations, the findings provide meaningful evidence that the physical workplace environment is an important determinant of treatment response in fungal infections. Overall, the study supports the hypothesis that air-conditioned environments are associated with better treatment outcomes, while non-air-conditioned settings may influence to delayed or incomplete recovery. Further longitudinal studies or clinical trials are recommended to validate these findings.

V. Conclusion

In conclusion, the employees in air-conditioned environments achieved significantly higher rates of complete cure from fungal infections than those in non-air-conditioned settings in our study. These findings demonstrate that successful treatment is not just about having the right medicine; it also depends on the environment where a person spends their majority of time in a day. Therefore, improving workplace conditions alongside proper medical management may contribute not only to reducing the burden of fungal infections but also to minimizing productivity loss, lowering healthcare expenditures, and ultimately enhancing the overall health and well-being of the working population.

Declaration

Ethics approval and consent to participate: The study was approved by the Ethical Review Committee. All the authors declare that no human subjects were harmed and that there were no procedures done with the participants. Informed written consent was obtained from all the participants.

Consent for publication: Not applicable.

Availability of data and materials: Data will be available upon request from the corresponding author.

Conflict of interest: The authors declare that they have no competing interests.

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Author contributions:

Conceptualization: MIC, NP, GRC, AKMSR and MMEK
Formal analysis: MIC, NP, and MMEK
Investigation: MIC, GRC and MMEK
Methodology: MIC, NP, AKMSR and MMEK
Resources: GRC, AKMSR and MMEK
Supervision: MIC, NP, GRC and MMEK
Writing: original draft: MIC, NP, GRC, AKMSR and MMEK
Writing – review & editing: MIC, NP and MMEK
All authors read and approved the final version of the manuscript

Reference:

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Table-1: Socio-demographic characteristics of the participants (n=100)

Characteristics	AC environment	Non-AC environment
Age (in years)	38.04±10.09	39.42±10.01
Sex distribution		
Male	35 (70.0)	28 (56.0)
Female	15 (30.0)	22 (44.0)
Residence		
Urban	11 (22.0)	14 (28.0)
Rural	39 (78.0)	36 (72.0)
Co-morbidities		
Diabetes mellitus	13 (26.0)	18 (36.0)
Hypertension	15 (30.0)	17 (34.0)
Ischemic heart disease	11 (22.0)	8 (16.0)
COPD	5 (10.0)	3 (6.0)
CVD	0	1 (2.0)

Table-2: Clinical symptoms and treatment protocol

Characteristics	AC environment	Non-AC environment
Symptoms		
Skin lesion	5 (10%)	18 (36%)
Circular rash	45 (90%)	35 (70%)
Itching	50 (100%)	50 (100%)
Pustules	15 (30%)	14 (28%)
Fever	1 (4%)	0
Infected focus	4 (8%)	11 (22%)
Treatment		

Only local	0	1 (2%)
Local+systemic	50 (100%)	49 (98%)

Table-3: Treatment response according to workplace environment of both groups (n=100)

Characteristics	AC environment	Non-AC environment	p-value
Treatment response			<0.001
Complete cure	44 (88%)	13 (26%)	
Partial cure	5 (10%)	28 (56%)	
Not responding	1 (2%)	9 (18%)	

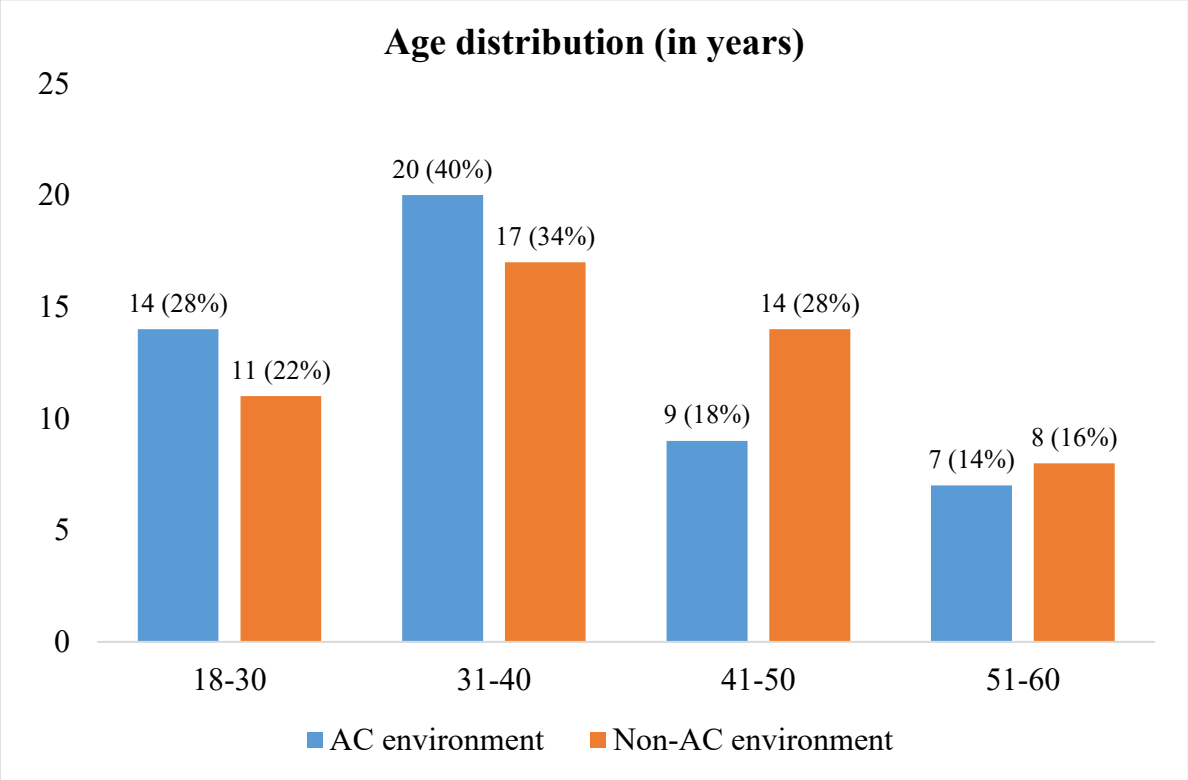

Figure-1: Age distribution of the participants (n=100)

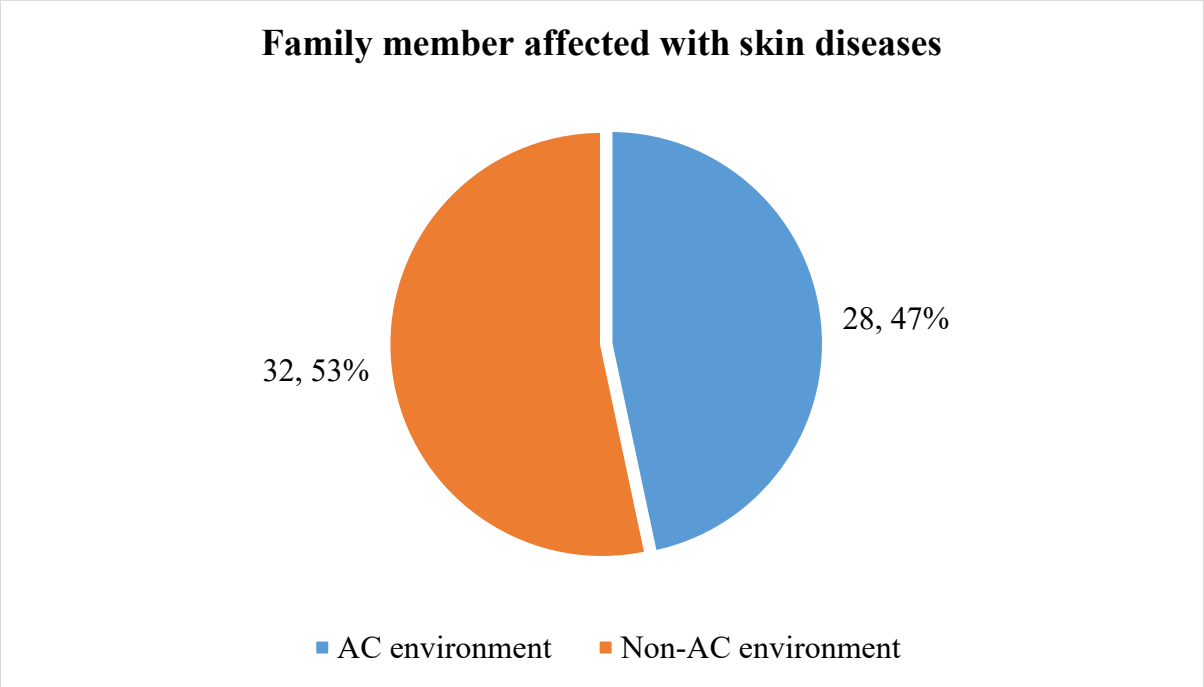

Figure-2: Frequency of family members affected with similar skin disease (n=100)