

The relationship between plant and humans in indoor environment: A pilot test during the COVID-19 pandemic

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Abstract. Little to no studies have examined the relationship between plants and humans during COVID-19, especially the effectiveness of plants in alleviating psychological distress when working in an office. The paper proposes a conceptual framework to investigate the existence of plants to reduce occupants' psychological distress during the pandemic. The selected site was a newly renovated office in an academic institution with all the essential furniture, and *Epipremnum aureum* was placed on the tabletop. Since the study was conducted during the pandemic, a 3D-rendered scene of the room was developed based on the actual settings of the office. A pilot test was employed in this stage of the study. The survey questionnaires were administered online, with 106 participants responding. Hayes Process Macro for moderation analysis was executed in SPSS v.23 to understand plant relationship with perceived emotional change, including the mediator-room's attractiveness. The pilot test results (actual and simulated models) show that putting *E. aureum* on a tabletop can positively influence the calmness of the indoor occupants and make them happy (direct effect). Plants that improve the room's attractiveness might not necessarily contribute to calming the indoor occupants, but they make them happy (indirect effect). Lastly, the conceptual framework provides insight to the designers, stakeholders, and policymakers on the importance of plants in reducing occupants' psychological distress and enhancing work productivity.

1 Introduction

Coronavirus disease 2019 (COVID-19) has been with us for up to three years since it was first reported on 31 December 2019. A cluster of cases of viral pneumonia was circulating in the media by the Wuhan Municipal Health Commission [1]. Malaysia in South-East Asia was once considered one of the most successful countries in curbing COVID-19 after a

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hundred days of total lockdown since the first Movement Control Order (MCO) was implemented from 18 March 2020 until 3 May 2020 [2]. To lessen the repercussions of the pandemic, the Malaysian government granted a considerable budget and various stimulus packages [3]. According to Ling et al. [4], enforcing strict lockdown measures and limiting non-essential activities can effectively reduce the risk of local transmission. Malaysian citizens also agreed that the government handled the pandemic adequately [5]. On 19 May 2021, the Ministry of Health Malaysia reported the highest recorded, reaching a new benchmark of 6075 confirmed cases [6]. It has significantly affected the Malaysian healthcare system, where a total lockdown is deemed necessary.

On 28 May 2021, a complete lockdown was announced by the prime minister's office in the media statement in the hope of flattening the curve once again, and all public are encouraged to stay at home [7]. Since then, the number of daily confirmed cases has fluctuated between 5000 to more than 8000 and peaked at 323,785 cases on 12 March 2022 (Fig. 1). Afterwards, the active cases have been slowed down, but not to be taken lightly, as new variants are emerging [8].



Fig. 1. COVID-19 Active cases in Malaysia from 25 January 2020 to 5 October 2022 (Source:[6]).

As time passed, most sectors have returned to the regular working routine, while some industries have shifted to work remotely. Nevertheless, new variants and subvariants, including Delta Plus, Omicron, and Arcturus coronavirus, also infiltrated Malaysia from time to time [8-10]. In this case, the choice to work from home, in an isolated space, or in a less crowded environment to prevent the spread of the virus is deemed mandatory. Positive impacts of working remotely include people being more satisfied because they can avoid traffic jams and have more flexibility in their working method, personal spaces, and work-life balance [11, 12]. On the contrary, rising evidence is associated with the negative impacts of working remotely. The most significant struggles are multi-tasking, uncomfortable spaces, and working extra hours [13]. For instance, parents must take care of their kids, do household chores, communicate with a colleague through video conferencing, and fulfil family demands simultaneously. In addition, Xiao et al. [14] also pointed out that lack of physical exercise and social interaction with co-workers, increased consumption of junk food, having a toddler nearby, and continuous distraction from external factors could potentially hamper the physical and mental health quality. Consequently, it may bring down work productivity, a decline in motivation, and an increase in stress-related disorders.

A few studies have examined office environments at academic institutions, like windowless workplaces, closed windows, north-facing window offices, and fabricated workplaces in a lab [15-18]. None of them looked at how different compositions of plants may help improve the room's condition, which may promote restorative effects and stress reduction. It also has been highlighted by Bringslimark et al. [19] that size, shape, species,

and colour might influence the relationship between plants and their outcomes. For instance, Qin et al. [17] suggest that small sizes and green plants provide the greatest satisfaction compared to medium, big-size and multicolour plants. However, they did not measure the placement of plants in different settings. Similarly, Yeo [20] also highlights that the inclusion of plants in the indoor environment is highly regulated by factors such as gender differences, the satisfaction of interior space, and the physical appearance of plants with their surrounding environment, which may affect the efficacy of stress reduction.

According to past studies, indoor environmental quality plays a vital role in human well-being, and interacting with plants can positively change psychological and physiological responses [21]. Due to the various direct and indirect benefits plants could offer, people have started integrating plants into different types of buildings [22, 23]. Previous investigations have emphasised the advantages of including plants in indoor environments underpinned by stress recovery theory and attention restoration theory [20, 24, 25]. Little to no study tests the situation during COVID-19, especially the effectiveness of plants in alleviating psychological distress when working in an office or home-like office. A conceptual framework is proposed to examine the human-plant relationship in an indoor environment (refer to Fig. 2). In this paper, we only tested the impact of a plant on perceiving emotional change (direct effect) and the aesthetic value (indirect effect).

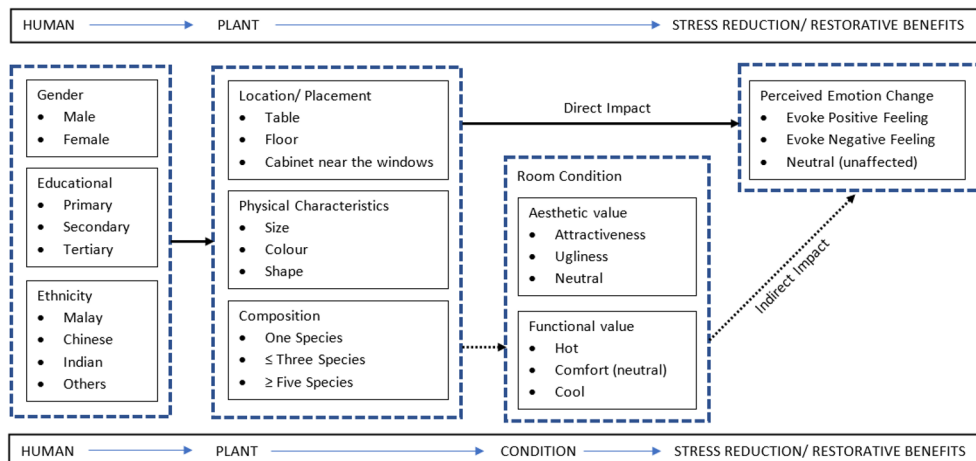


Fig. 2. Conceptual model of human-plant relationship in an indoor environment.

2 Methods

The site is at a college in Petaling Jaya, Selangor, Malaysia. Fig. 3 shows the layout plan of an office room for a lecturer. The room's height is 2,700mm with a dimension of 3,250mm x 4,230mm. The room has a cabinet, a pedestal, a desktop computer, a table, and an adjustable chair with dark carpet flooring. The room itself is relatively new and rarely used. All the walls and ceiling were painted white, with no decorative elements. The space was selected as the experimental area to prevent external factors that may infer the results. Next, we placed the most common indoor plant species in the indoor environment, *Epipremnum aureum*, into our constructed model [20]. There are two windows in the experimental site. One is 840mm (width) x 2100mm (height) at the front wall, facing the co-working space, while the other is at the rear side facing the north direction, so the interior light condition is relatively bright with a non-glare effect.

For this study, we developed a 3D model using computational modelling to represent the natural indoor environment of an academic institution. We created a simulated environment

mainly to reduce the cost and time to set up the entire office with various plants during the pandemic and to minimise close contact. It is considered a novel approach using an actual image of the site and a computer-generated image for experimentation. The parameter of attractiveness was measured based on bipolar adjectives adapted from the study of Lohr and Pearson-Mims [26], and mood, emotion and perceived stress were based on the circumplex model of Russell [27], Russell [28]. The questions were measured on a 5-point Likert scale supported with pictures, as shown in Fig. 3. Whitehead et al. [29] suggest that a minimum of 50 sets is required. Hence, we prepared the Google form and distributed it through social media such as WhatsApp and Facebook. Our targeted respondents for the pilot study are more than required, with which 106 respondents answered the survey questionnaires. All the data were analysed using Hayes Process Macro for moderation analysis [30]. Note that this study only measured the direct effect of plant placement on a tabletop influencing the room's attractiveness, happiness, and calmness, and an indirect impact of attractiveness affects the happiness and calmness of the indoor occupants.



Fig. 3. A floor plan, views of a person seated on a chair in an office (A & B), and a simulated model (C & D).

3 3. Analysis, Result, and Discussion

3.1 Actual office environment

Based on the result shown in Fig. 4 (A), the existence of *Epipremnum aureum* in a tabletop has a significant impact on the attractiveness of the office ($b=0.6914$, $t=11.7316$, $p<0.00$). The direct effect of *E. aureum* on the stress reduction (calmness) of indoor occupants is also significant ($b=0.6089$, $t= 8.2844$, $p<0.00$). Meanwhile, the room's attractiveness toward the calmness of indoor occupants is not significant ($b=0.1317$, $t=1.6414$, $p>0.05$). The indirect effect of plant \rightarrow clam is 0.0911, and the 95% confidence limits include zero (BootLLCI -0.0022 and BootULCI 0.1937). Thus, the indirect effect test is insignificant. The result in Fig. 4 (B) shows *E. aureum* has a significant impact on the attractiveness of office ($b=0.6914$, $t= 11.7316$, $p<0.00$) and happiness ($b=0.5122$, $t= 6.8427$, $p<0.00$). Similarly, the office's attractiveness significantly impacts happiness ($b=0.1952$, $t= 2.3891$, $p<0.05$). The indirect effect of plant \rightarrow happy is 0.1350, and the 95% confidence limit does not include zero (BootLLCI -0.0147 and BootULCI 0.2805). Thus, the indirect effect test is statistically significant.

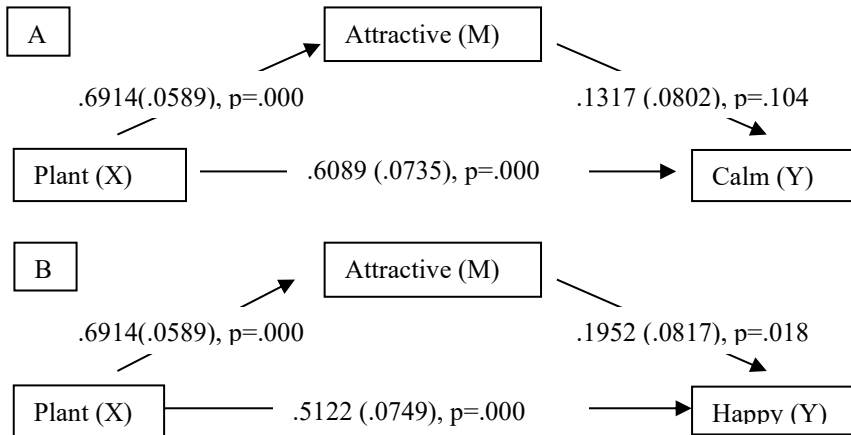


Fig. 4. The indirect effect of the plant on calmness (A) and happiness (B) with attractiveness as a mediator, an actual view of an office.

3.2 Simulated office environment

Surprisingly, the mediation analysis for the simulated site for Fig. 5 (A) and Fig. 5 (B) are all statistically significant. From Fig. 5 (A), the direct effect of *E. aureum* on the attractiveness of the room and stress reduction are both significant ($b=0.7636, t= 15.3421, p<0.00$; $b=0.5023, t= 6.2772, p<0.00$). The room's attractiveness toward indoor occupants' calmness also exhibits the same result ($b=0.4545, t=5.2097, p<0.00$). The indirect effect of plant \rightarrow clam is 0.3471, and the 95% confidence limit does not include zero (BootLLCI 0.1625 and BootULCI 0.5577). Thus, the indirect effect test is statistically significant. The result in Fig. 5 (B) shows *E. aureum* has a significant impact on the attractiveness of the room ($b=0.7636, t= 15.3421, p<0.00$) and happiness ($b=0.2539, t= 3.2586, p<0.00$). Similarly, the office's attractiveness significantly impacts happiness ($b=0.5696, t= 6.7045, p<0.00$). The indirect effect of plant \rightarrow happy is 0.4350, and the 95% confidence limit does not include zero (BootLLCI 0.2794 and BootULCI 0.5839). Thus, the indirect effect test is statistically significant.

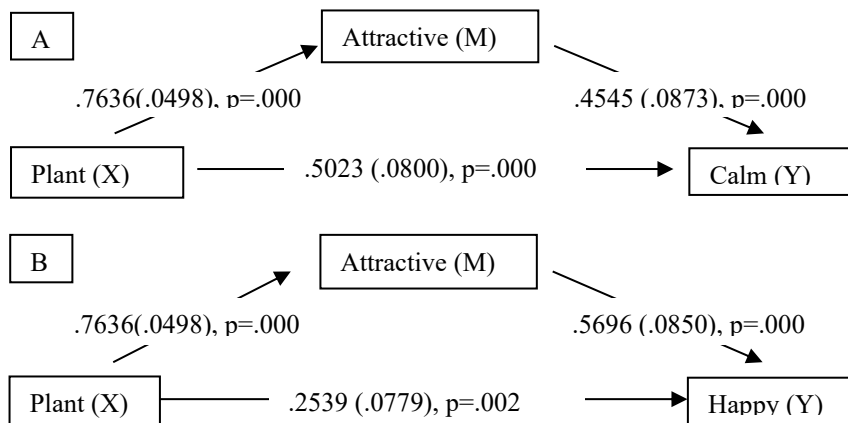


Fig. 5. The indirect effect of the plant on calmness (A) and happiness (B) with attractiveness as a mediator, a simulated model.

The results of both the actual and simulated models demonstrated that putting *E. aureum* on a table can positively influence the indoor occupants' calmness and make them happy. However, the indirect effect of mediation analysis for the calmness attribute (restoration effect) shows different patterns. The actual site model demonstrates that a plant can improve the room's attractiveness, but the room condition does not afford any restoration effect. Meanwhile, the simulated model shows that a plant can enhance the calmness of indoor occupants, directly or indirectly. The discrepancy between the actual and simulated model might be due to the variation of exterior views, which might infer the accuracy of the result (refer to Fig. 3). The actual picture of the model shows that the indoor occupants can see outdoor components, including the co-working space and a pink mounting board. Meanwhile, the simulated model exterior view is empty. This also has been highlighted by Abdul Hamid et al. [31]; spatial layout and visual elements can significantly influence human emotions and behavioural intentions. In this case, the simulated model may provide a more reliable outcome to study the effectiveness of plants in stress reduction and restoration since it does not consider exterior views and factors. However, in reality, all the external factors are essential to reflect on because that is not something the indoor occupants can control, as executive management regulates the interior design of an office.

4 Conclusion

The COVID-19 virus has now become endemic in most countries. As a result, people have adapted to a new normal lifestyle that combines face-to-face and virtual activities. Flattening the curve of the virus in a short time now seems almost impossible. The benefits of indoor plants towards psychological response and physiological health are well reported. Yet, more studies need to examine how including plants in an office environment affects indoor occupants, particularly during COVID-19. This paper has found several notable findings and an approach to studying human and plant relationships. It can sum up as follows:

- Plant (*E. aureum*) can positively impact the indoor occupants' perceived emotional change (calmness and happiness). It also improves the room's aesthetic value (attractiveness).
- The actual model shows room attractiveness does not afford any restorative effect (calmness), while the simulated model shows the other way around.
- The simulated model might be a more viable approach since it is designed under a controlled environment without external factors, for instance, visual elements. Building the model in a virtual setting is also cost-effective before implementing it in the office environment.

Although our study provides valuable insights, it is essential to note that our sample size is relatively small. As a result, the regression coefficient in our mediation analysis may be affected. Therefore, we cannot draw conclusions based solely on the weight of the coefficient. In most cases, direct effect regression coefficients are higher than indirect effect coefficients, indicating that the attractiveness attribute may not be a mediator, except in the simulated model shown in Fig. 5(B). In the future, we aim to investigate all attributes highlighted in the conceptual model (Fig. 2) and incorporate artificial intelligence and machine learning to simulate indoor office environments. This study provides a framework for understanding plants' direct and indirect impacts on indoor occupants. It can help upper management, designers, stakeholders, and policymakers make informed decisions about providing a stress-free and productive office environment.

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