frontiers | Frontiers in Built Environment

TYPE Original Research
PUBLISHED 12 February 2025
DOI 10.3389/fbuil.2025.1544177

OPEN ACCESS

EDITED BY
Fan Zhang,
Griffith University, Australia

REVIEWED BY
Roberto Alonso González-Lezcano,
CEU San Pablo University, Spain
Haifeng Lan,
Hong Kong Polytechnic University, Hong Kong SAR, China

*CORRESPONDENCE
Ismar M. S. Usman,
ismarms@ukm.edu.my

RECEIVED 20 December 2024
ACCEPTED 20 January 2025
PUBLISHED 12 February 2025

CITATION
Abdulaali HS, Usman IMS, Alawi M and Alqawzai S (2025) Research on guest comfort and satisfaction with indoor environmental quality in former GBI-certified green hotels: a study case from Malaysia.
Front. Built Environ. 11:1544177.
doi: 10.3389/fbuil.2025.1544177

Research on guest comfort and satisfaction with indoor environmental quality in former GBI-certified green hotels: a study case from Malaysia

Hayder Saadoon Abdulaali[1,2], Ismar M. S. Usman[1]*, Mohsen Alawi[3] and Shagea Alqawzai[4]

[1]Department of Architecture and Built Environment, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia, [2]College of Engineering, University of Thi-Qar, Nasiriyah, Iraq, [3]School of Architecture and Urban Planning, Chongqing University, Chongqing, China, [4]School of Civil Engineering, Chongqing University, Chongqing, China

This study examines the impact of Indoor Environmental Quality (IEQ) on guest comfort and satisfaction in former Green Building Index (GBI)-certified green hotels in Malaysia's historic cities, including Kuala Lumpur, Melaka, and Penang. With many hotels moving away from certification, it highlights the need to maintain high environmental and comfort standards. The research evaluates IEQ performance, suggests additional parameters, and explores how comfort mediates the relationship between IEQ and satisfaction. Eight hypotheses were tested, focusing on indoor air quality (IAQ), thermal comfort, lighting, acoustics, visual comfort, building features, decoration, and indoor greenery. A survey of 700 hotel guests resulted in 384 valid responses, confirming that IEQ significantly influences comfort and satisfaction. Among the factors, acoustic/noise (Beta = 0.305), IAQ (Beta = 0.221), and building characteristics (Beta = 0.167) were the most impactful, followed by thermal comfort, lighting, decoration, visual comfort, and indoor greenery. Regression analysis showed a strong link between guest comfort and satisfaction, with comfort as a key mediator. Challenges included noise, thermal discomfort, and lighting problems. The study emphasizes the importance of air quality, thermal comfort, and noise management while balancing aesthetic elements like greenery and decoration to improve guest experiences. It offers valuable insights for hotel operators, advancing sustainable practices and guest satisfaction in green-certified hotels.

KEYWORDS

guest comfort, guest satisfaction, indoor environmental quality (IEQ), former green hotels, sustainability

1 Introduction

Hotels are designed to offer exceptional comfort and a wide range of services, catering to guests accustomed to and willing to invest in exclusive amenities, personalized treatment, and premium entertainment (Asadi et al., 2011). Among the most valued amenities by guests are a comfortable indoor environment, safety, and reliability. In recent years, sustainability has emerged as a central focus in the global

hospitality industry. Green hotels, in particular, are leading the way by minimizing environmental impacts while enhancing guests' experiences. These hotels adopt energy and water conservation practices, waste management, and use sustainable materials to reduce their ecological footprint and preserve the natural environment for future generations (Fossgard and Fredman, 2019; Zhang et al., 2020; Fernandez-Antolin et al., 2022).

In the hotel industry, indoor environmental quality (IEQ) has become an essential indicator influencing the satisfaction of customer (Xu et al., 2022). IEQ is a key aspect of sustainable architecture, which plays a critical role in shaping hotel guest experience, directly affecting their health, satisfaction, productivity, and loyalty. IEQ encompasses various factors such as Indoor Air Quality (IAQ), thermal comfort, lighting, acoustics, and overall spatial design. It was also revealed that other performance indicators, such as building characteristics, indoor decoration, indoor greenery, furniture and furnishing, cleaning and maintenance, and privacy significantly influence the comfort of the building occupants (GBI, 2022; Abri, 2009). IEQ is a key element in green building certification systems because it directly contributes to the wellbeing of occupants and the overall performance of the building (Al horr et al., 2016; Mallawaarachchi et al., 2016). Factors such as air quality, thermal comfort, acoustics, and indoor greenery significantly influence occupants' wellbeing, satisfaction, and overall perception of a space. Poor IEQ can lead to discomfort, reduced productivity, and negative guest feedback, while optimized environmental conditions enhance comfort and engagement. Green building certification systems, such as BREEAM (UK), LEED (USA), DGNB (Germany), ITACA (Italy), and Malaysia's Green Building Index (GBI), prioritize IEQ to ensure healthy and comfortable indoor environments (Shan and Hwang, 2018; LEED, 2018). However, while the environmental benefits of green buildings are well-documented, the influence of IEQ on guest satisfaction in green hotels, particularly after certification expiration, remains underexplored.

Guest comfort and satisfaction, particularly with IEQ, are essential factors in determining the success of green hotels. Several studies have been conducted on the IEQ in offices (Esfandiari et al., 2021; Devitofrancesco et al., 2019), residential buildings (Piasecki et al., 2017), and commercial hotels. Limited studies have investigated hotel guests' perceptions of IEQ in green hotels. For example, Qi et al. (2017) analyzed the IEQ issues in five-star hotels in China using text-mining methodology. The study found that air conditioning, noise, and humidity were the key IEQ issues affecting guest satisfaction. Poor IEQ also led to lower online ratings, indirectly impacting hotel business performance. Besides, Buso et al. (2017) investigated the indoor comfort conditions and valuations of guests in Italian hotel rooms. The study revealed that hotel guests highly value improved indoor comfort and are willing to pay 14% more for better conditions. In addition, Shen et al. (2021) assessed the IEQ in the top five brand hotels in China using the text-mining approach. The study found that budget hotels had high IEQ complaints, especially regarding acoustics. Complaints were influenced by seasonal, regional, and customer-type factors, with IAQ and thermal issues having the greatest impact on ratings. The causes of IEQ problems were concentrated, suggesting areas for targeted improvements. Through a systemic literature review, Abdulaali et al. (2024) studied the relationship between IEQ and guests' comfort and satisfaction at green hotels. The study identified that air quality, thermal comfort, and lighting were the key IEQ factors affecting guest comfort and satisfaction in green hotels. A conceptual model was proposed to evaluate these factors, providing a valuable tool for hotel management to enhance IEQ and enhance guests' experiences.

While previous studies highlight the impact of IEQ on guest comfort in green hotels, few examine the performance of former GBI-certified green hotels in Malaysia, particularly regarding IEQ. As many GBI-certified hotels transition away from certification, understanding how IEQ continues to influence guest satisfaction is crucial, as these hotels typically offer better comfort than traditional buildings (Ravindu et al., 2015). Only one study has examined the relationship between GBI IEQ parameters and guest comfort in Malaysian GBI-certified green hotels before and after certification expired (Abdulaali et al., 2020a). However, there is a lack of detailed research on IEQ parameters and guest satisfaction in former GBI-certified hotels, especially in Malaysia's key tourist destinations. Concerns also exist about whether sustainability and comfort standards are maintained once certification lapses. This study addresses this gap using a post-occupancy survey to evaluate IEQ performance and guest feedback in former GBI-certified green hotels in cities like Kuala Lumpur, Melaka, and Penang. The study emphasizes ongoing monitoring to ensure long-term sustainability and comfort. It offers feedback and data for the hotel management to take actionable recommendations to optimize the effects of IEQ parameters on the experiences of hotel guests. The main objectives of this study are as follows:

(a) To measure the indoor environmental comfort in former GBI-certified green hotel guestrooms in Malaysian historical cities.
(b) To propose new IEQ parameters and evaluate their impact on the comfort and satisfaction of guests in former GBI-certified green hotels in Malaysian historical cities.
(c) To correlate comfort as a mediator between the indoor environment of the former GBI-certified green hotel guestrooms and the satisfaction of hotel guests in Malaysian historical cities.

2 Literature review and development of hypotheses

2.1 Relationship between IEQ and guest comfort and satisfaction

IEQ significantly affects the hotel guests' health, comfort, and satisfaction. High IEQ standards, such as good IAQ, thermal comfort, and appropriate acoustics and lighting, can reduce health issues and complaints, ultimately enhancing guest loyalty and hotel performance (Catalina and Iordache, 2012; Turunen et al., 2014). Several studies have examined the relationship between IEQ and guest satisfaction. For instance, Gayathri and PB (2016) found that green hotels provide better IEQ than conventional ones, although acoustics and lighting still present challenges. Qi et al. (2017) identified air conditioning, humidity, and noise as the key factors affecting guest satisfaction, with poor IEQ correlating to higher complaint rates and energy consumption. Wei et al. (2020)

highlighted IAQ as the most significant factor in guest satisfaction, followed by acoustics and thermal comfort. Shen et al. (2021) and Abdulaali et al. (2020a) both emphasized thermal comfort and acoustics as the most influential factors in green hotels, with IAQ and lighting having less impact. Other studies, such as Borowski et al. (2022), demonstrated that high CO_2 concentrations in IAQ negatively affect guest comfort. Additionally, Suhag and Maan (2022) noted that environmental communication in green hotels affects guest loyalty, while Hu and Dang-Van (2023) found that guest affectivity and brand value mediate the relationship between IEQ and revisit intention. Based on these findings, it is evident that the IEQ factors, such as IAQ, thermal comfort, lighting, visual comfort, acoustics, building characteristics, indoor decoration, and indoor greenery, influence guest comfort and satisfaction in green hotels. Therefore, the following Hypothesis is assumed:

H1: IEQ parameters (IAQ, thermal comfort, lighting, visual comfort, acoustics, building characteristics, decoration, and indoor greenery) significantly influence green hotel guests' comfort and satisfaction in Malaysian historical cities.

IAQ is a key aspect of IEQ that impacts the guest comfort and satisfaction in green hotels. Pollutants from the surrounding environment, building features, and indoor activities influence it (Abdulaali et al., 2020b; Laquatra et al., 2008; Roelofsen, 2002; Canha et al., 2012). Poor IAQ can lead to health issues, such as asthma, respiratory problems, skin rashes, fatigue, and Sick Building Syndrome (SBS), which includes symptoms like headaches and dizziness, ultimately reducing guest satisfaction (Fraga et al., 2008; EPA, 2022; Akar-Ghibril and Phipatanakul, 2020; Sarkhosh et al., 2021). Several studies have demonstrated that poor IAQ negatively influences hotels' guest satisfaction. Kuo et al. (2008) revealed that inadequate ventilation caused many complaints from guests in Taiwanese hotels. Gayathri and PB (2016) indicated the serious health effects of poor IAQ, such as SBS and respiratory issues. Recent studies also indicated that hotels with better IAQ, particularly regarding fresh air and ventilation, receive higher guest satisfaction and booking intentions, especially among health-conscious travelers (Wu et al., 2021; Sun et al., 2021). It was also evident that IAQ was observed to affect customer loyalty, with high IAQ standards directly linked to enhanced guest satisfaction and retention (Kim et al., 2023). Overall, IAQ is a crucial parameter to guest comfort and satisfaction in green hotels, where a good IAQ helps create a healthier, more comfortable environment, leading to higher satisfaction and loyalty. Therefore, the current study evaluates the relationship between IAQ and guest comfort and satisfaction in former GBI-certified green hotels in Malaysian historical cities, including Kuala Lumpur, Melaka, and Penang. The following Hypothesis is assumed:

H1a: Indoor Air Quality (IAQ) significantly influences green hotel guests' comfort and satisfaction in former GBI-certified green hotels in Malaysian historical cities.

Thermal comfort refers to the state of satisfaction with the thermal environment, influenced by air temperature, velocity, and relative humidity (ASHRAE, 2015). It is a key component of IEQ, significantly affecting occupant comfort, including sleep quality, which is particularly important for hotel guests (Olesen, 2007; Okamoto-Mizuno and Mizuno, 2012). Thermal comfort is influenced by both personal factors (e.g., physical condition and clothing) and environmental factors (e.g., air temperature, velocity, and humidity) (Mamani et al., 2022; Saad et al., 2017; Hua et al., 2014). Ensuring thermal comfort is essential for creating a comfortable indoor environment and enhancing guest satisfaction in green hotels. Several studies have highlighted the impact of thermal comfort on hotel guest comfort and satisfaction. Allen et al. (2015) found that thermal comfort significantly influences health, satisfaction, and productivity. Sahid et al. (2019) noted that solar radiation affects room temperature, influencing thermal comfort. Arsad et al. (2023) reported that optimal thermal conditions enhance guest satisfaction, leading to higher return visits and positive reviews, while poor thermal conditions result in discomfort, negative reviews, and reduced loyalty. Based on previous studies, thermal comfort is a key parameter of IEQ that significantly affects guest comfort and satisfaction in green hotels. Maintaining optimal thermal conditions is particularly important in former GBI-certified green hotels, which aim to balance sustainability and guest comfort. Thus, the following Hypothesis is assumed for the study:

H1b: Indoor thermal comfort (TC) significantly influences green hotel guests' comfort and satisfaction in former GBI-certified green hotels in Malaysian historical cities.

Lighting is a critical aspect of IEQ that affects building occupants' physical and psychological health and wellbeing. It also influences comfort and satisfaction. Natural daylight, in particular, enhances occupant satisfaction, psychological comfort, and work productivity. Green buildings often utilize natural light to improve visual comfort and reduce energy consumption. Proper lighting, including both natural and artificial sources, is essential to create a healthy and productive environment for hotel guests (Huang et al., 2012; Hwang and Jeong, 2011; Xiao et al., 2021; Huiberts et al., 2016). Previous research highlights the health effects of insufficient lighting, including eye irritation, headaches, and allergic reactions (Boyce, 2014). The absence of natural daylight can negatively impact performance and wellbeing, while adequate lighting improves morale, energy efficiency, and productivity (Boyce, 2014). Daylight exposure has been linked to better health outcomes, including reduced seasonal anxiety (Boyce, 2014). Research by Chang and Lin (2022) and Preziosi et al. (2022) showed that adequate lighting, especially in green hotels, enhances guest comfort and satisfaction. Integrating energy-efficient, aesthetically pleasing lighting solutions can improve the overall hotel experience. Based on previous studies, it has been revealed that lighting in green hotels significantly influences guest comfort and satisfaction, enhancing their overall experience and perception of the hotel. Effective lighting design contributes to ambiance, wellbeing, and functionality. Therefore, the current study examines the relationship between indoor lighting and green hotel guests' comfort and satisfaction in green-certified hotels in Malaysia's historic cities, including Kuala Lumpur, Melaka, and Penang, with the following Hypothesis has been assumed:

H1c: Indoor Lighting significantly influences guests' comfort and satisfaction in former GBI-certified green hotels in Malaysian historical cities.

Visual comfort in green hotels is key to guest satisfaction and is affected by natural elements like plants and daylight, which reduce stress and improve wellbeing (Kwong, 2020; Wirz-Justice et al., 2021). Proper natural and artificial lighting enhances mood and comfort, while poor lighting can lead to eye strain, headaches, and

reduced productivity (Lu et al., 2020; Kharvari and Rostami-Moez, 2021). Biophilic design and glare control are crucial for creating a pleasant, stress-free environment (Liu et al., 2021; Bedrosian and Nelson, 2017). Effective lighting design, ensuring adequate illumination and light uniformity, is essential for guest comfort and satisfaction in green hotels (Sharif et al., 2016; Serghides et al., 2015). It was reported that the wall color (i.e., rose, blue, yellow, and green) in the guestroom can improve building occupants' focus, mood, and productivity (Wei et al., 2017). Based on previous studies highlighting Visual Comfort as a key IEQ parameter, the current research explores its relationship with guest comfort and satisfaction in green-certified hotels in Malaysia's historic cities, including Kuala Lumpur, Melaka, and Penang, with the following Hypothesis has been assumed:

H1d: Indoor Visual Comfort significantly influences guests' comfort and satisfaction in former GBI-certified green hotels in Malaysian historical cities.

Acoustic comfort refers to a building's ability to protect its occupants from disturbing noise and provide a quiet, secure environment that supports communication, concentration, and overall wellbeing (Claudi et al., 2019). Factors like sound pressure levels, frequency, distance, sound absorption, insulation, and Reverberation Time (RT) influence acoustic comfort (Dong et al., 2021; Tsirigoti et al., 2020; Nowicka, 2020; Ramlee et al., 2021; Kim A. et al., 2019). In hotels, noise can stem from both natural (e.g., wind, waves) and human sources (e.g., traffic, appliances), and inadequate acoustic design can lead to increased customer complaints and dissatisfaction (Jafari et al., 2019; Baliatsas et al., 2016; Yao and Zhao, 2017). Ensuring good acoustic quality in hotel environments is critical for guest comfort and satisfaction. Shen et al. (2021) listed several indoor acoustic quality complaints in Chinese budget hotels, which include poor sound insulation, lousy sound insulation, no sound insulation, very noisy, relatively noisy, a little noisy, loud noise, severe noise, audible noise, some noise, and loud voice. Based on previous studies that emphasized acoustic as one of the critical parameters of IEQ, the current research pursued the relationship between Acoustic with green hotel guests' comfort and satisfaction in green-certified hotels in Malaysian historical cities, including Kuala-Lumpur, Melaka, and Palau Pinang, with the following Hypothesis developed:

H1e: Indoor Acoustic/noise significantly influences green hotel guests' comfort and satisfaction in former GBI-certified green hotels in Malaysian historical cities.

Building characteristics, including location, climate, design, and construction, ensure high IEQ and occupant comfort. As highlighted in previous studies, the building envelope, such as facades and materials, plays a significant role in maintaining energy efficiency and protecting occupants from external environmental conditions. Jin (2017) emphasized that selecting the best facade can reduce solar radiation and improve indoor quality. Patnaik et al. (2018) also noted that building characteristics like climate, location, and design are integral to IEQ. By focusing on energy-efficient design, green buildings optimize both environmental sustainability and occupant comfort. For green hotels, the effectiveness of these building components can significantly influence guest satisfaction and comfort. Therefore, this study investigates the relationship between building characteristics and guest satisfaction in GBI-certified hotels in Malaysian historical cities, with the following Hypothesis:

H1f: Building characteristics significantly influence guests' comfort and satisfaction in former GBI-certified green hotels in Malaysian historical cities.

Hotel decoration plays a significant role in shaping guests' perceptions and satisfaction, especially in green hotels. Various decoration styles, including furniture layouts, materials, and plant configurations, have been adopted to enhance the aesthetic appeal and emotional impact of the hotel environment. Studies show that interior design influences guests' emotional experiences and interpersonal relationships with the hotel environment, including lighting, furniture, and decorations. This can contribute to a more memorable stay and increased satisfaction. Functional elements, like decoration, plants, and artwork, enhance the IEQ, leading to better guest comfort. Patnaik et al. (2018) researched to evaluate and explain the IEQ parameters and its effect on green buildings. It was found that building characteristics (i.e., location, climate, design and construction, optimal temperature zone, and thermal insulation) significantly influence the IEQ within the building. Bortolini and Forcada (2021) indicated that building characteristics significantly influence IEQ perceptions and user satisfaction in buildings. According to Lam et al. (2011) aesthetic elements such as architecture, interior design, and decoration are key contributors to the attractiveness and satisfaction of green buildings.

H1g: Indoor decoration significantly influences guests' comfort and satisfaction in former GBI-certified green hotels in Malaysian historical cities.

Indoor greenery, such as plants, green walls, and natural light through glass windows, is crucial in creating sustainable and resilient hotel environments. These nature-based solutions (NBS) contribute to a hotel's aesthetic appeal and improve guest satisfaction by enhancing wellbeing. Previous studies have shown that indoor greenery positively impacts occupant satisfaction, reduces stress, and improves mental health. For example, (Moya et al., 2019), found that greenery in office spaces helps reduce sound levels, while Han et al. (2020) reported that indoor green spaces in hotels significantly enhance guests' perceptions of wellbeing. Moreover, indoor vertical greenery has been linked to improved visual satisfaction, according to (Xiao et al., 2022). Based on these findings, the current study investigates the relationship between indoor greenery and green hotel guests' comfort and satisfaction in historical cities in Malaysia, with the following Hypothesis:

H1h: Indoor Greenery significantly influences guests' comfort and satisfaction in former GBI-certified green hotels in Malaysian historical cities.

2.2 Relationship between hotel guests' comfort and satisfaction

The relationship between hotel guests' comfort and satisfaction is vital in the hospitality industry. Comfort includes physical aspects like room quality, amenities, temperature, noise levels, cleanliness, and psychological comfort, such as ambiance, lighting,

decor, and staff interactions. These factors directly influence guest satisfaction. Studies, such as Ariffin and Aziz (2012), emphasized that the physical environment, including comfort, strengthens the correlation between hospitality quality and guest satisfaction. It was shown that guests are more satisfied when their comfort needs are met. Psychological comfort, including a welcoming atmosphere and friendly staff, enhances satisfaction. Hotels assess comfort through guest feedback, which helps them understand how factors like thermal comfort, lighting, IAQ, noise, and visual environment affect satisfaction. While the relationship between comfort and satisfaction is established, its full impact, particularly in green hotels, is still being explored. Comfort is key to guest satisfaction, influencing loyalty and overall experience. Rhee and Yang (2015) found that comfort directly impacts guest loyalty, which results from high satisfaction. Ariffin et al. (2018) identified comfort, personalization, and sincerity as key factors in enhancing guest satisfaction. Mohammed and Rashid (2018) stressed that hotels must meet guest expectations to stay competitive, with comfort being a primary determinant of satisfaction. Berezan et al. (2013) found that green practices positively affect guest satisfaction and revisit intentions, though the impact varies by nationality. Gao and Mattila (2014) showed that guest satisfaction in green hotels is influenced by service outcomes, warmth, and competence, with green hotels performing better when service delivery is successful. Zareh et al. (2023) confirmed that satisfaction is higher in green hotels when green practices are seen as serving the public good rather than the hotel's self-interest. Based on previous studies that emphasized green attributes, the current study pursued the relationship between green hotel guests' comfort with their satisfaction in green-certified hotels in Malaysian historical cities, including Kuala Lumpur, Melaka, and Palau Pinang, in guidance with the following Hypothesis developed:

H2: There is a significant relationship between the comfort and satisfaction of green hotel guests and the IEQ in former GBI-certified green hotels in Malaysia's historical cities.

2.3 Guest comfort mediates the relationship between guest satisfaction and IEQ

Guest comfort mediates the relationship between guest satisfaction and IEQ in green hotels. A good indoor environment is closely linked to guest satisfaction and wellbeing, positively influencing comfort and emotional states, such as happiness and relaxation (Abdulaali et al., 2020c). Research shows that a high-quality IEQ contributes to positive feelings, wellbeing, and higher satisfaction (Mujan et al., 2019), directly impacting health, emotions, and productivity (Kim J. et al., 2019). Solomon (2018) and Dang et al. (2021) also highlight that comfort resulting from a positive IEQ can lead to favorable perceptions and experiences, influencing consumer behavior and purchase intentions in physical spaces. Rahmiati et al. (2024) investigated how guest experiences at different stages of a trip (pre-trip, on-trip, and post-trip) affect guest satisfaction and loyalty within Indonesia's accommodation sector, finding that while these experiences influence satisfaction, they indirectly impact loyalty through satisfaction, emphasizing the importance of excellent service throughout the entire guest journey. Moreover, studies on green luxury hotels demonstrate that a good IEQ creates feelings of comfort, satisfaction, and excitement, which increases the likelihood of revisits (Dang et al., 2021; Maula et al., 2016; Das and Varshneya, 2017; Garaus et al., 2017). Therefore, comfort plays a key role in mediating the relationship between guest satisfaction and the quality of the indoor environment in green hotels.

Based on existing literature emphasizing GBI post-occupancy comfort surveys, the current study focuses on evaluating the comfort performance of green hotels, mainly through the lens of guest comfort and satisfaction in green-certified hotels located in historical cities in Malaysia, including Kuala Lumpur, Melaka, and Pulau Pinang. The study aims to explore how IEQ and comfort influence guest satisfaction and loyalty in these green hotels. The following Hypothesis has been developed to guide this study:

H3: Guest comfort mediates the relationship between guest satisfaction and IEQ in former GBI-certified green hotels in Malaysian historical cities.

2.4 Development of research framework

Figure 1 presents a conceptual framework linking IEQ parameters to guest comfort and satisfaction in former green-certified hotels. It contains the eight IEQ parameters, including IEQ, thermal comfort, lighting, visual comfort, acoustic comfort, building characteristics, decoration, and indoor greenery, as independent variables that directly impact guest comfort (H1a–H1h). Guest comfort is hypothesized to directly impact guest satisfaction (H2), highlighting its critical role in enhancing the overall guest experience while also mediating the relationship between IEQ parameters and guest satisfaction (H3), indicating that the effect of IEQ on satisfaction is partially or fully explained by its influence on comfort. The figure visually maps these relationships, incorporating building characteristics and decoration as moderating variables to emphasize their additional impact on the IEQ-comfort link. This framework provides a comprehensive understanding of the dynamics between environmental quality, guest comfort, and satisfaction, guiding Hypothesis development and advancing sustainable hospitality research. Summarizing these relationships visually aids researchers and practitioners in identifying areas for optimizing guest experiences, emphasizing the mediating role of comfort, and implementing targeted interventions to enhance environmental quality and satisfaction in green-certified hotels.

3 Research methods

3.1 Design of research instrument

The questionnaire is a widely used tool for data collection. It is a popular unbiased quantitative approach that measures the reactions of participants to a phenomenon (Creswell and Creswell, 2017). Based on the previous literature and the theoretical background presented in Section 2, a semi-structured questionnaire was developed to collect survey data from former GBI-certified hotel

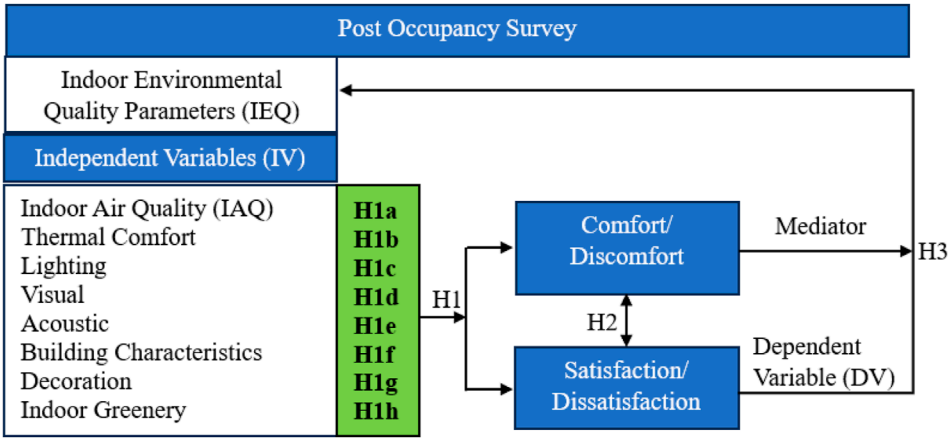

FIGURE 1
Research frameworks.

guests regarding their perceptions, comfort, and satisfaction with the IEQ parameters (Creswell and Creswell, 2017). The questionnaire was then sent for review by three academic researchers who had experience in questionnaire design to obtain feedback for improving the content of the questionnaire.

The final version of the questionnaire (see Supplementary Material) is divided into five sections, each focusing on different aspects of IEQ and guest experiences in green hotels, as summarized in Table 1 and graphically depicted in Figure 2. Section A gathers personal information about the participants, including gender, nationality, age, familiarity with green building concepts, and frequency of staying in green hotels. Section B collects hotel-specific details, such as the hotel name, booking recurrences, room-sharing arrangements, room orientation, and the purpose of the stay. Section C assesses participants' perception of core GBI-IEQ parameters, including indoor air quality, thermal comfort, lighting, visual appeal, and acoustic conditions, based on (Gayathri and PB, 2016). Section D expands the GBI-IEQ parameters by exploring additional IEQ factors, such as building characteristics, indoor decoration, and indoor greenery, with references to Patnaik et al. (2018) and Lee et al. (2019). Finally, Section E evaluates guests' comfort and satisfaction with the overall IEQ in the hotel, also referencing (Gayathri and PB, 2016). This structured approach allows for a comprehensive understanding of how different IEQ elements influence guest experiences in green hotel environments. The questionnaire uses standard response options, such as multiple-choice checkboxes, five-point Likert scales for measuring perceptions and satisfaction, and closed and open-ended questions to capture quantitative and qualitative data. The Likert scale options provided were: (very unsatisfied/very uncomfortable), (unsatisfied/uncomfortable), (neutral), (satisfied/comfortable), (very satisfied/very comfortable).

3.2 Population and sample size

The general population for this study consists of hotel guests from formerly GBI-certified green hotels located in Malaysia's historical cities. According to Tourism Malaysia (Tourism Malaysia, 2013), there are 435 hotels in Kuala Lumpur, 327 in Melaka, and 310 in Pulau Pinang in 2023. These hotels supply hotel rooms (hotel guests) of 57,286 (19,622,098), 19,851 (917,131), and 20,558 (1,320,388) totaling 97,695 hotel rooms, which accommodates hotel guests of 19,622,098, 917,131, and 1,320,388, totaling 21,859,617 in Kuala Lumpur, Melaka, and Pulau Pinang, respectively. This study selected five former GBI-certified green hotels, as shown in Table 2, where certification status, location, validity dates, building category, and room supply are provided. These former GBI-certified hotels include Hotel A (Penang, Gold-rated, 40 rooms), Hotel B (Melaka, Gold-rated, 151 rooms), Hotel C (KL, Certified, 483 rooms), Hotel D (KL, Silver-rated, 322 rooms), and Hotel E (KL, Gold-rated, 252 rooms). The total room supply across these hotels is 1,348. All are categorized as Non-Renewal New Construction (NRNC).

The sample size is critical in any quantitative study, as it ensures valid conclusions can be drawn about the population. A random sample must be large enough to allow for generalization and minimize sampling errors or biases (Taherdoos, 2017). Determining the correct sample size is often challenging, as it must accurately represent the characteristics of the population (Dattalo, 2008). In this study, the sampling process is designed to ensure that the sample of hotel guests from Malaysian historical cities is representative, specifically focusing on former GBI-certified green hotels. The room supply percentage in the GBI-certified hotels is first predicted (Equation 1) and then used to forecast the number of hotel guests for the five selected former GBI-certified hotels (Equation 2), as follows:

$$\text{Room Supply in percentage} = \frac{\text{GBI certified hotel}}{\text{All hotels in historical area}} = \frac{1348}{97695} = 1.38\% \quad (1)$$

$$\begin{aligned} &\textit{Forecasted hotel guests numbers} \\ &= (\% \times \textit{All hotels guests number}) \\ &= 1.38\% \times 21,859,617 = 301,663 \text{ hotel guests} \end{aligned} \quad (2)$$

The sample size for a population of 301,663 hotel guests in historical cities (Kuala Lumpur, Melaka, and Penang) is calculated

TABLE 1 Content and profiling of questionnaire.

Section	Question No.	Content	Source
A	Personal Information		
	1–5	Gender	Own
		Nationality	
		Age	
		Familiarity with the green building concept	
		Stay recurrences in the green hotel	
B	Hotel Information		
	1–5	Name of hotel	
		Hotel booking recurrences	
		Number of people sharing the hotel room	
		Direction of hostel room	
		Purpose of hotel stay	
C	Perception of the GBI-IEQ parameters performance		
	11–15	Indoor Air Quality (IAQ)	Gayathri and PB (2016)
	16–19	Thermal comfort	
	20–25	Lighting	
	26–33	Visual/View	
	34–36	Acoustic/Noise	
D	Perception of additional IEQ parameters performance		
	37–43	Building characteristics	Patnaik et al. (2018)
	44–46	Indoor decoration	Lee et al. (2019)
	47–49	Indoor greenery	
E	50–52	Comfort and satisfaction of hotel guests with IEQ parameters	Gayathri and PB (2016)

with a 95% confidence level and a 5% margin of error (Equation 3). The population size represents the total number of respondents, while the margin of error indicates how much the survey results can deviate from the actual population value. A 95% confidence level means there is a 95% certainty that the results fall within the specified range. The formula used is:

$$sample\,size = \frac{z^2 \times p(1-p)}{e^2} = 1 + \left(\frac{z^2 \times p(1-p)}{e^2 N} = \right) = 384 \qquad (3)$$

where z is the z-score, p is the population proportion, e is the margin of error, and N is the population size.

3.3 Data collection procedure

A series of focus group interviews were carried out to develop and check different sections of the questionnaire and a pre-test was sent out to 20 respondents before the final version was sent out. To provide sufficient information, interviews with focus groups were also conducted to check and improve different sections of the questionnaire regarding instruction, wording, and sentence composition. A pre-test was performed by sending the questionnaire to 20 respondents before the final version.

After revisions, the main survey was launched in April 2024, with 700 questionnaires distributed through various methods, including in-person delivery, mailing, WhatsApp, and online platforms. During their stay, paper surveys were given to guests,

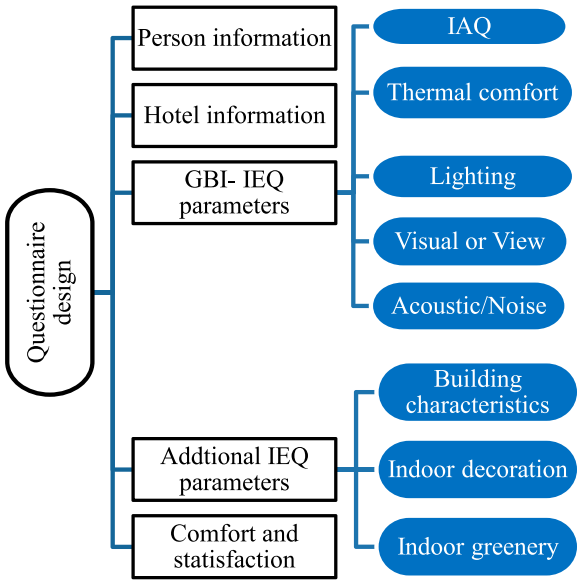

FIGURE 2
Questionnaire design framework.

while online surveys were sent via email or Google Forms. Face-to-face distribution was the most effective in encouraging participation, though online surveys offered greater convenience and flexibility. Despite these efforts, challenges such as respondent reluctance, logistical issues, and the absence of some target respondents affected the response rate. The combination of paper and online surveys aimed to ensure broad participation, but inconsistencies in direct contact with participants impacted data collection.

3.4 Response rate

In this study, the response rate is a crucial metric in evaluating the reliability and validity of the research's findings. Table 3 summarizes the questionnaire's response rate, where 700 questionnaires were distributed among hotel guests at five hotels in Malaysian historical cities. Of the 700 distributed questionnaires, 535 were returned, resulting in an initial response rate of 76.4%. However, not all returned questionnaires were useable. A total of 151 questionnaires, representing 21.6% of those distributed, had to be excluded from the analysis due to incomplete responses. As a result, the number of useable questionnaires was reduced to 384, leading to a final useable response rate of 54.9%. The final response rate of 54.9% is suitable to provide a substantial data set for analyzing guest comfort and satisfaction with Indoor IEQ in the context of the selected hotels.

4 Analysis and results

4.1 Personal and hotel information

Figure 3 presents the demographic distribution of respondents based on five key characteristics, including gender, nationality, age, familiarity with green buildings, and recurrences of stay in green hotels. It is observed from Figure 3. Demographic information of the respondents. Figure 3A shows that most participants were male (71.1%), while females account for about 28.9%. Regarding nationality, 56.5% were Malaysian, and 43.5% were non-Malaysian, as shown in Figure 3B. In terms of age, the majority of respondents were aged 30–39 years (31.5%), followed by those aged 50–59 (28.9%), 40–49 (17.7%), and below 30 (16.7%), with smaller proportions in the over 60 age group (5.2%), as indicated in Figure 3C. It can be observed from Figure 3D that most respondents were slightly familiar with the concept of green building, accounting for 35.9%, followed by those who were moderately familiar, comprising 23.2% of the total respondents. Additionally, 21.1% were unfamiliar with the concept, while 19.8% were very familiar. Regarding repeat/recurrence stays in green hotels, 63.3% had visited before, while 36.7% had not, as illustrated in Figure 3E.

4.2 Information on former GBI-certified green hotels

Figure 4 represents the information collected from guests about their stays in former GBI-certified green hotels, highlighting their preferences and behaviors. As illustrated in Figure 4A, most guests have booked 1–2 times 37.2%, followed by 39.9% of guests who have booked 0–1 time, indicating limited loyalty to the hotel guests. 18.8% and 8.1% of hotel guests have booked 3–4 and more than 4 times, respectively. From Figure 4B, room-sharing patterns varied among guests, with 35.2% sharing a room with one other person, 28.9% with two others, 16.9% staying alone, and 13.3% sharing with more than three individuals. As depicted in Figure 4C, the most common directions were North-East (23.2%) and South-East (22.7%), followed by North-West (14.3%), South-West (9.6%), and West (9.1%). Rooms facing South (7.9%) and North (7.3%) were less frequent, while East-facing rooms were not explicitly reported. Natural light, thermal comfort, scenic views, or cultural norms may influence these preferences. Additionally, it is revealed from Figure 4D that the primary purposes of guests' stay are 39.0% visiting for leisure, 35.2% for tourism, and 24.7% for business. Overall, these findings provide significant insights into guest behavior, preferences, and expectations within the context of green hotels.

4.3 IEQ related-issues in former GBI-certified hotels

4.3.1 Indoor air quality (IAQ)

Figure 5 illustrates the health issues related to IEQ in former GBI-certified green hotels. It is revealed that the most frequently reported IAQ-related health concerns among hotel guests include fatigue/lethargy and feelings of heaviness in the head, with a significant proportion of responses falling under the "often" and "sometimes" categories. Drowsiness and headaches were also commonly reported, although to a lesser extent. Moderate symptoms, such as coughing, nasal irritation or congestion, and a hoarse or dry throat, were observed, indicating variability in guest experiences. In contrast, issues such as nausea/vomiting,

TABLE 2 Expired GBI-certified hotels with "certified" status.

GBI hotels	GBI rating	Location	Validity date	Building category	Room supply
Hotel A	Gold	Penang	9th December 2016–8th December 2019	NRNC	40
Hotel B	Gold	Melaka	29th November 2017-28th November 2020	NRNC	151
Hotel C	Certified	KL	15 February 2019–14 February 2022	NRNC	483
Hotel D	Silver	KL	14 August 2018–13 August 2021	NRNC	322
Hotel E	Gold	KL	October 2017 - 8 October 2020	NRNC	252
			Total room supply		1,348

Note: NRNC, is the Non-Residential New Construction, hotel A is Hotel Penaga, hotel B is Kings Green Hotel, hotel C is VE, Hotel and Residence, hotel D is Movenpick Hotel and Convention Centre KLIA, and hotel E is The Ruma Hotel and Residences.

TABLE 3 The response rate of the questionnaire.

Description	Number	Percentage (%)	Response rate (%/)
Number of questionnaires sent	700	100	
The number of questionnaires returned	535	76.4	76.4
Number of discarded questionnaires	151	21.6	
Number of useable questionnaires	384	54.9	54.9

skin rashes/itchiness, eye irritation, and itching or scaling of the scalp or ears were less frequently reported, with higher frequencies in the "never" category. While specific IAQ-related health issues were prevalent, others were infrequent, indicating that the targeted improvements to IAQ could enhance the comfort and satisfaction of guests in these hotels. Addressing these concerns, this study highlights the importance of improved air circulation, pollutant reduction, and ventilation strategies in mitigating IAQ-related health symptoms. By identifying key problem areas, the findings can guide the development of more effective IAQ interventions, ultimately enhancing the wellbeing and experience of hotel guests.

4.3.2 Thermal comfort

Figure 6 depicts the distribution of guest perceptions of temperature and airflow in hotel rooms, assessed on a five-point Likert scale. For temperature, most responses were around 3 (Neutral) and 4 (Comfortable), indicating general comfort, but some neutral or slightly less comfortable guests. Similarly, airflow ratings mainly were 3 (Neutral) and 4 (Sufficient), suggesting adequate but not optimal airflow. While most guests were not dissatisfied, there is room for improvement in temperature and airflow to enhance comfort and meet guest expectations in former GBI-certified green hotels. Based on these findings, this study highlights that optimizing thermal comfort can be achieved by addressing guest perceptions of temperature control and airflow.

4.3.3 Lighting

Figure 7 illustrates the distribution of responses to lighting-related issues, rated on a five-point scale. Most respondents rated natural light, natural glare, artificial light, and artificial glare around the mid-range, with peaks at a scale of 3 (Neutral). Approximately 40% of responses for both artificial light and natural glare were centered around scale 3, indicating balanced perceptions. While most guests found lighting adequate or moderate, there were some variations, with fewer extreme ratings (1 or 5). This suggests that while guests are generally satisfied, there is room for improvement in balancing natural and artificial light and reducing discomfort.

4.3.4 Visual comfort or view

Figure 8 depicts the distribution of responses regarding visual comfort issues. The most common concern, reported by 35% of respondents, was "unsystematic, unorganized room layout," highlighting the importance of room organization. "Insufficient lighting" was reported by nearly 25%, while 15%–20% cited issues like "too much/oversized furniture" and "facility breakdowns." The least common concern was the "lack of outdoor views." These findings stress the need for better layout, lighting, and furniture arrangements to improve visual comfort.

4.3.5 Acoustic/noise

Figure 9 illustrates the distribution of responses regarding the impact of noise or interruptions during guests' stays. About 40% of respondents reported being "frequently" affected by noise (scale 4), while 30% experienced it "sometimes" (scale 3). Around 20% were "very frequently" affected (scale 5). Fewer respondents reported minimal noise impact (scales 1 and 2). These findings indicate that noise is a significant concern for many guests, highlighting the need for better noise control measures to improve guest comfort. These

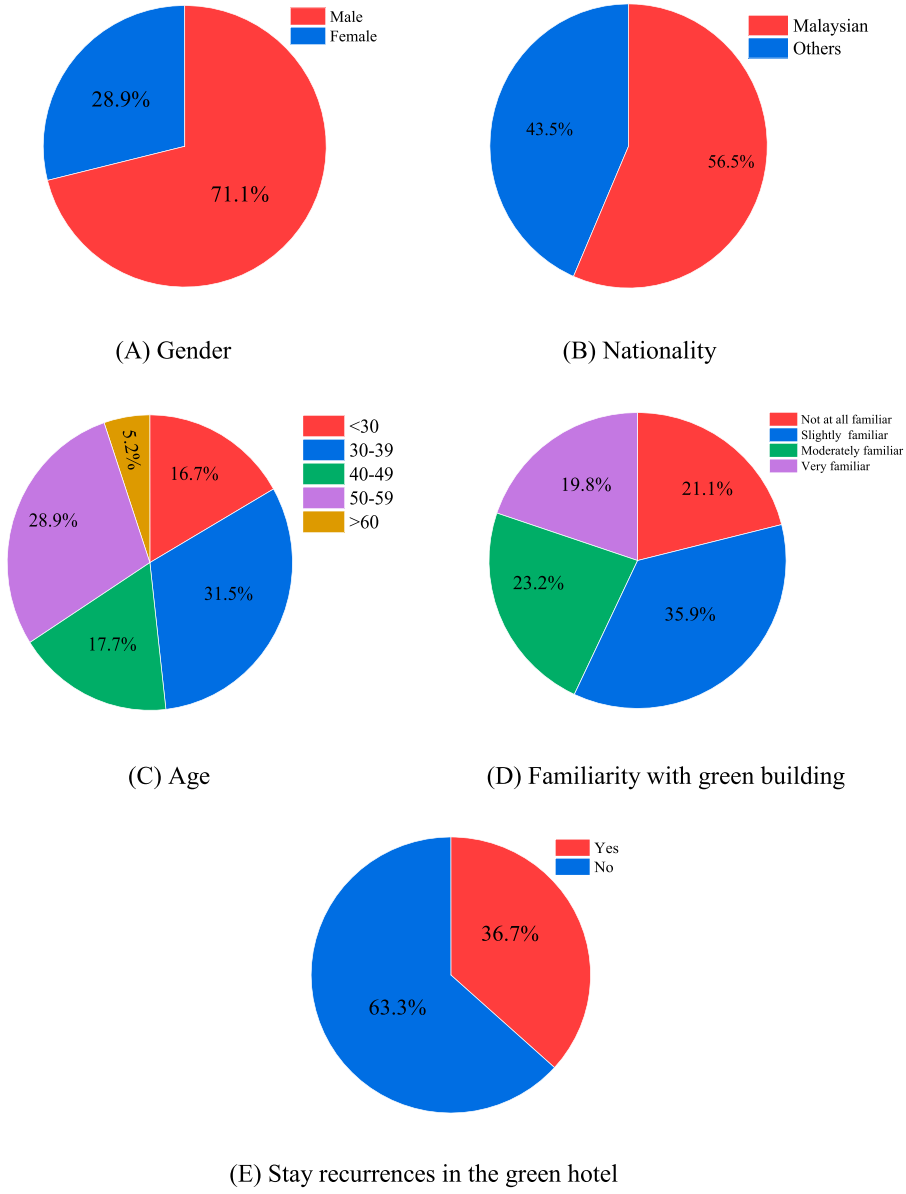

FIGURE 3
(A) Gender. **(B)** Nationality. **(C)** Age. **(D)** Familiarity with green building. **(E)** Stay recurrences in the green hotel. Demographic information of the respondents.

insights can inform future hotel design strategies aimed at creating quieter environments, enhancing guest satisfaction, and reducing the negative impact of noise on the overall guest experience.

4.3.6 Building characteristics

Figure 10 represents the distribution of responses for building characteristics related to guest comfort. For Location (see Figure 10A), 22% rated it as Very Suitable, 25% were Neutral, and 17% found it Unsuitable. For Climate (see Figure 10B), 30% rated it as Very Suitable, with 24% Neutral and 16% Unsuitable. Design and Construction (see Figure 10C) had 27% rating it as Good, 24% as Neutral, and 15% as Very Bad, indicating mixed satisfaction. For the Optimal Temperature Zone (see Figure 10D), 35% rated it as Very Good, with 28% as Good and only 6% as Very Bad. Thermal Insulation (see Figure 10E) showed 32% rating it as Sufficient, while 11% found it Very Insufficient. Overall, guests were generally satisfied with the location, climate, temperature, and insulation, but the design and construction needed improvement.

4.3.7 Indoor decoration and greenery

Figure 11 shows the distribution of responses for indoor decoration and greenery issues affecting guest comfort. For the Amount of Interior Decoration (see Figure 11A), most respondents rated it as Neutral (Zhang et al., 2020), with 30% selecting this option, followed by Good (Fernandez-Antolin et al., 2022), indicating a balanced level of decoration. For Environmentally Friendly Materials (see Figure 11B), most respondents rated it as Good (Fernandez-Antolin et al., 2022), with some selecting Neutral

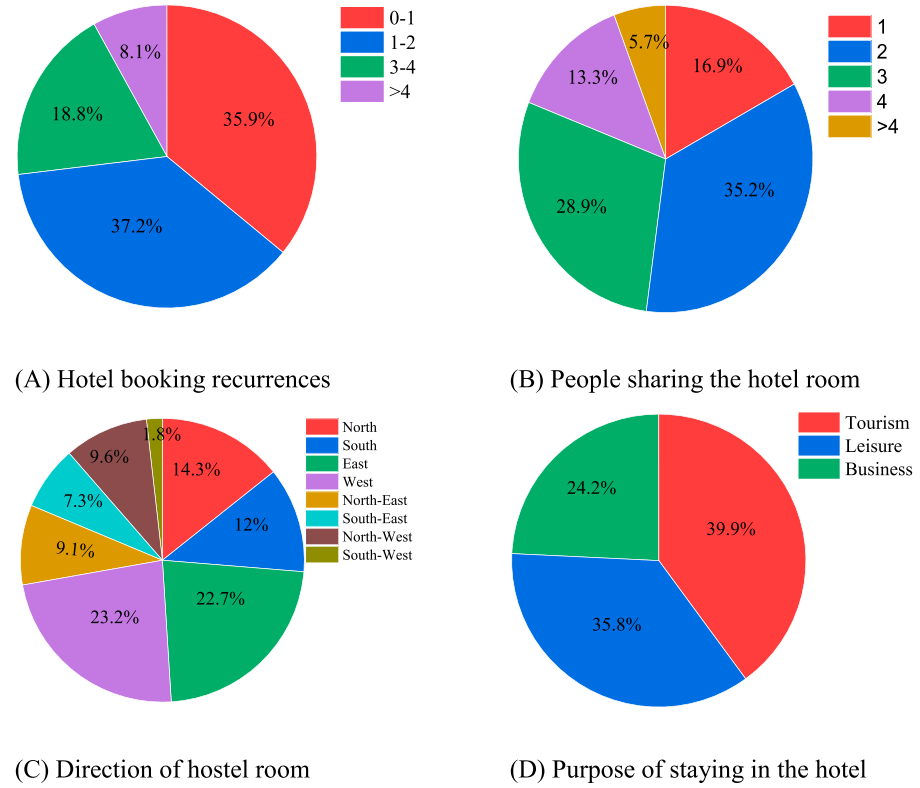

FIGURE 4
(A) Hotel booking recurrences. **(B)** People sharing the hotel room. **(C)** Direction of hostel room. **(D)** Purpose of staying in the hotel. Information on former GBI-certified green hotels.

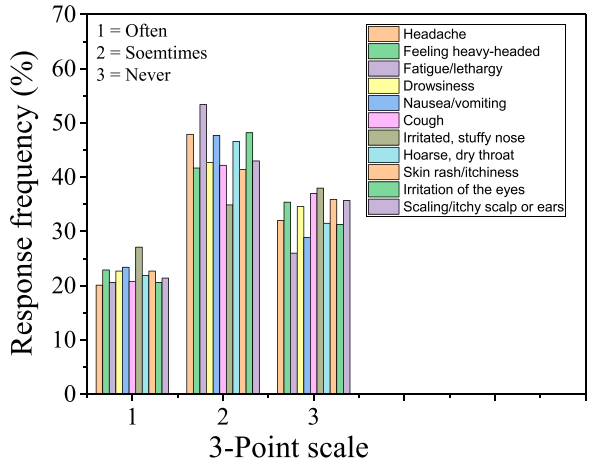

FIGURE 5
IAQ health-related issues.

(Zhang et al., 2020), showing general appreciation but limited strong preference. For Indoor Greenery (see Figure 11C), responses were divided between Good (Fernandez-Antolin et al., 2022) and Neutral (Zhang et al., 2020), with 22% rating it as Very Good (Xu et al., 2022), suggesting that guests appreciate greenery, but many consider it adequate. Overall, the results indicate that guests prefer a balanced amount of decoration and greenery, enhancing comfort without being overwhelming.

4.4 Descriptive statistics

Figure 12 illustrates the response frequency (%) for IEQ parameters in terms of perception, comfort, and satisfaction, assessed using a five-point Likert scale across factors such as IAQ, thermal comfort, lighting, visual/view, acoustic/noise, building characteristics, indoor decoration, and indoor greenery. In all three aspects, including the perception of IEQ performance, IEQ and guests' comfort, and IEQ and guests' satisfaction, the responses predominantly focus on neutral (Zhang et al., 2020) and satisfied (Fernandez-Antolin et al., 2022) ratings, indicating moderate levels of acceptability and comfort. Lower frequencies at the extremes (Asadi et al., 2011; Xu et al., 2022) reflect fewer participants perceiving these aspects as either very unsatisfactory or very satisfactory. Consistent response patterns across parameters suggest a uniform perception of IEQ, with indoor greenery and visual/view scoring relatively higher and thermal comfort and acoustic/noise rating slightly lower, highlighting areas for improvement to enhance both comfort and satisfaction.

Table 4 summarizes the descriptive statistics of IEQ factors, overall comfort, and satisfaction in former GBI-certified hotels. Mean values range from 2.914 (acoustic/noise) to 3.057 (thermal

10.3389/fbuil.2025.1544177

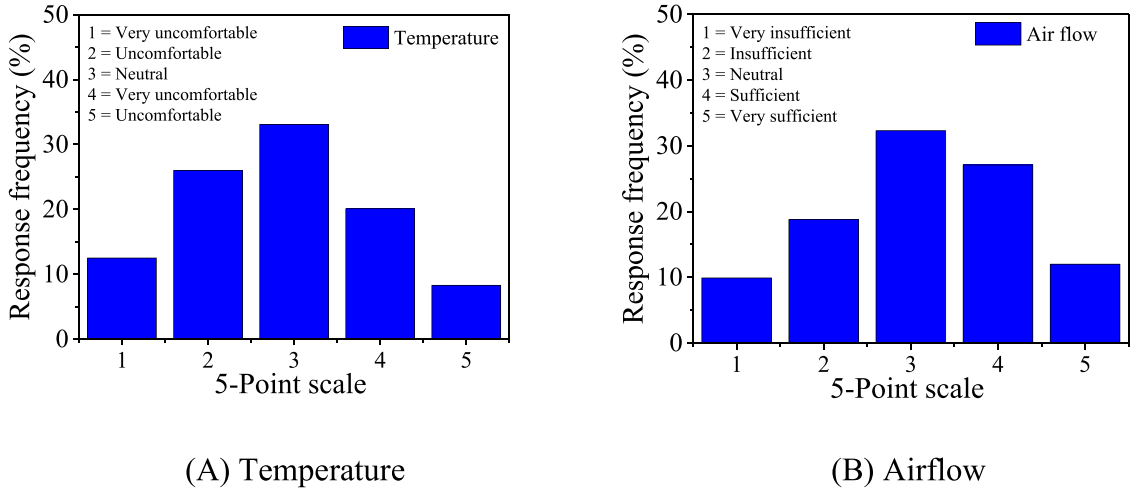

FIGURE 6
(A) Temperature. **(B)** Airflow. Thermal comfort-related issues.

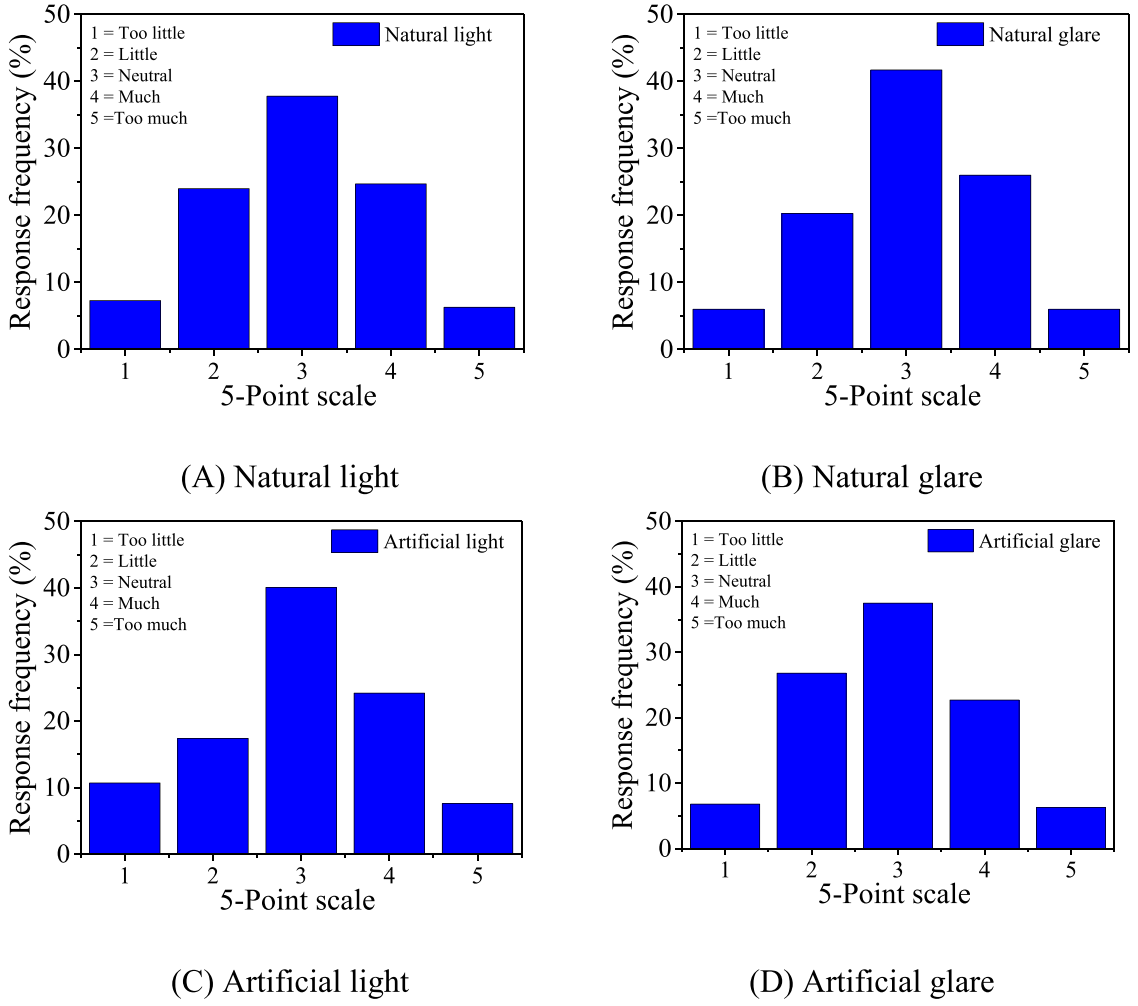

FIGURE 7
(A) Natural light. **(B)** Natural glare. **(C)** Artificial light. **(D)** Artificial glare. Lighting-related issues.

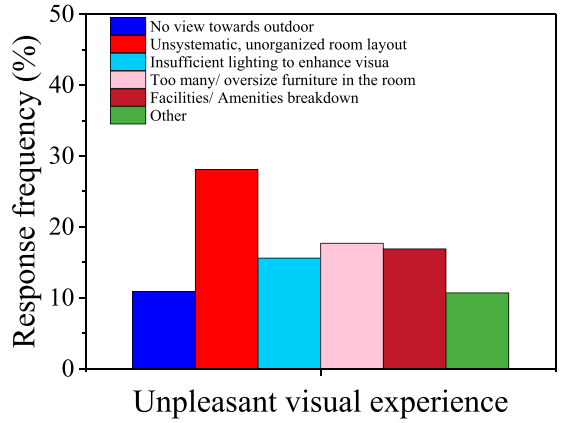

FIGURE 8
Visual comfort/view-related issues.

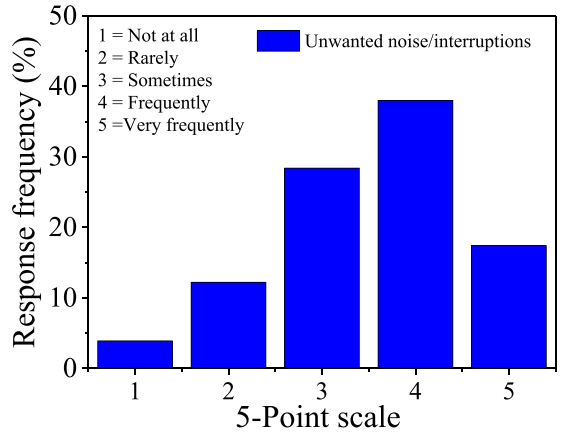

FIGURE 9
Acoustic/noise-related issues.

comfort), reflecting neutral to slightly positive guest perceptions, with thermal comfort being the least favorable and acoustic/noise being the least. Overall comfort (2.967) and satisfaction (3.014) indicate moderate guest experiences. Minor standard errors (0.01837–0.05470) demonstrate high precision, while standard deviations reveal that lighting (1.072) is the most varied factor and thermal comfort (0.971) is the most consistent. Skewness values are close to zero, indicating balanced distributions, with minor negative skewness for lighting (−0.164) and thermal comfort (−0.115), showing a slight bias toward positive ratings. Negative kurtosis across most factors suggests flatter distributions with fewer extreme values, except for Comfort (0.080) and Satisfaction (0.14), which cluster closer to the mean. These results highlight areas for improvement, particularly in acoustic/noise, lighting, and indoor greenery, to enhance guest satisfaction and comfort. Skewness and kurtosis values near zero suggest symmetrical distributions and a lack of extreme ratings, further confirming the reliability of the data. Overall, the findings of this study revealed moderate satisfaction and comfort, with lighting, acoustic/noise, and indoor greenery offering opportunities for improvement to enhance guest experiences further. This study provides valuable insights into guest perceptions while highlighting areas for improvement to enhance comfort and satisfaction.

4.5 Reliability analysis

Table 5 presents the results of Cronbach's alpha reliability analysis. It can be seen that Cronbach's alpha values are in the range of 0.75–0.94, which considered as acceptable values, indicating the perfect good internal consistency and reliability. The Cronbach's alpha values for the various aspects of IEQ in GBI-certified green hotels in Kuala Lumpur, Melaka, and Pulau Pinang reveal strong internal consistency for most parameters. IEQ and comfort, and IEQ and satisfaction received the highest reliability scores, both with Cronbach's alpha of 0.94, indicating very high consistency in the items measuring guest comfort and satisfaction with IEQ. Thermal comfort and IAQ attained Cronbach's alpha of 0.87 and 0.86, respectively, which also displayed high internal reliability, showing that guests' responses to these aspects were very consistent.

Building characteristics, and indoor decoration and greenery showed Cronbach's alpha of 0.83 and 0.82, respectively, which had slightly lower but still high reliability, demonstrating strong coherence in guest feedback for these factors. Cronbach's alpha of acoustic/noise is 0.78, showing moderate internal consistency with only two items, while Lighting had the lowest reliability score at 0.75, which, although still acceptable, indicates somewhat less consistency in responses about lighting quality compared to other aspects of IEQ. Notably, no Cronbach's alpha was reported for the visual or view parameter, likely due to insufficient or missing data for this category. Overall, the results demonstrate that guest feedback on IEQ aspects like comfort, air quality, thermal conditions, and building characteristics is highly reliable, with lighting and noise showing relatively lower but still acceptable consistency.

4.6 Correlation analysis

Table 6 presents the Spearman's rho correlation of IEQ parameters with guests' comfort and satisfaction. It is observed that all IEQ parameters significantly impacts the guests' comfort and satisfaction, with varying levels of impact. Overall IEQ has the strongest correlation with comfort and satisfaction, emphasizing the critical role of holistic environmental quality management. Among the individual parameters, IAQ, thermal comfort, lighting, visual comfort/view, and building characteristics are the strongest drivers, showing high correlations with both comfort and satisfaction. IAQ and thermal comfort stand out as the most influential factors for comfort and satisfaction, indicating their direct impact on guest wellbeing. Acoustic/noise control (AC) also plays a significant role for comfort and satisfaction of guests, reinforcing the importance of a quiet and relaxing environment. While indoor decoration (ID) and indoor greenery (IG) show moderate correlations with comfort and satisfaction, they enhance the aesthetic and psychological appeal of the spaces. Comfort serves as a strong mediator between IEQ with satisfaction, indicating that guest satisfaction is largely dependent

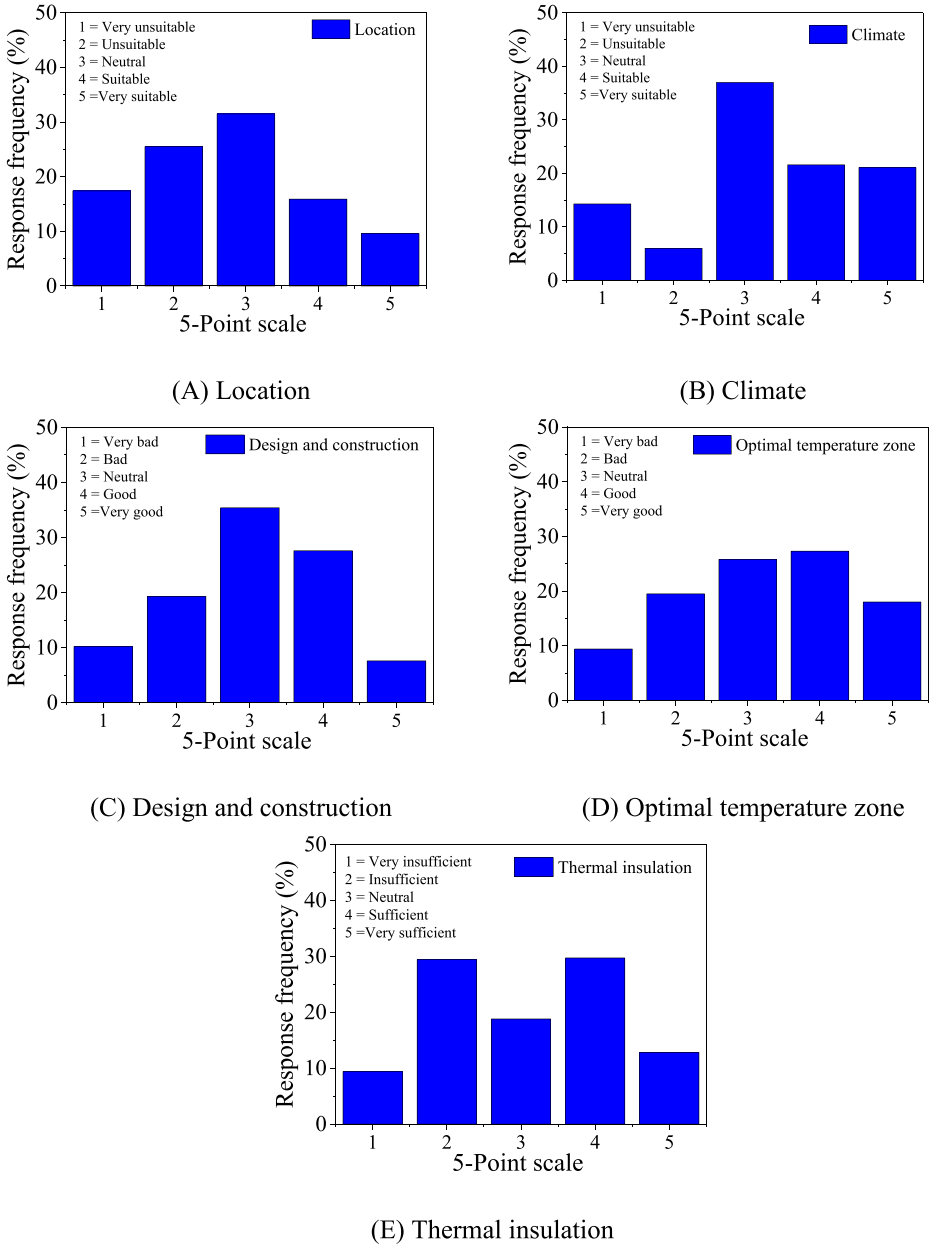

FIGURE 10
(A) Location. **(B)** Climate. **(C)** Design and construction. **(D)** Optimal temperature zone. **(E)** Thermal insulation. Building characteristics-related issues.

on their comfort levels. These findings underline the need for a balanced approach to optimizing both functional and aesthetic IEQ parameters in green hotels, with a particular focus on IAQ, temperature, and lighting to create a comfortable and satisfying guest experience.

This study suggests that the quality of indoor environmental conditions plays a significant role in impacting guests' comfort and overall satisfaction. The strong correlations between various IEQ parameters (such as indoor air quality, thermal comfort, lighting, and acoustic conditions) and guests' comfort and satisfaction indicate that maintaining high standards in these areas can lead to better experiences for occupants. Specifically, the study highlights that comfort serves as an essential mediator between IEQ factors and satisfaction, implying that enhancing comfort can amplify the positive effects of IEQ on guest satisfaction.

4.7 Multiple regression analysis

Table 7 summarizes two regression models, where Hotel gests' satisfaction is selected as dependent variable (DV), while IEQ parameters and comfort are selected as independent variables (IV). Model 1 includes detailed predictors/independent variables, such as IAQ, thermal comfort, lighting, visual comfort, acoustic/noise,

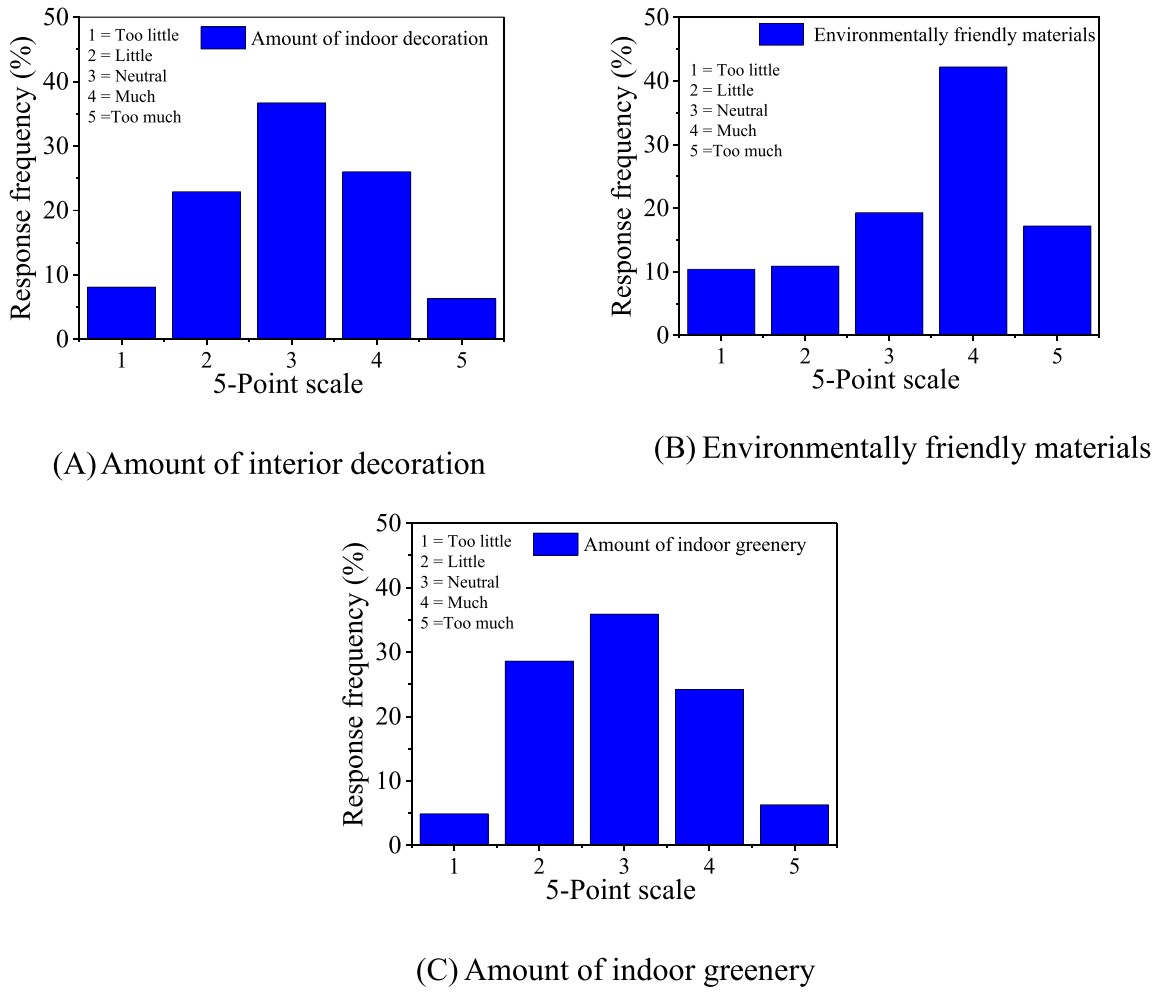

FIGURE 11
(A) Amount of interior decoration. **(B)** Environmentally friendly materials. **(C)** Amount of indoor greenery. Indoor decoration and greenery-related issues.

building characteristics, interior decoration, and indoor greenery, where the results indicate an excellent fit. Its low standard error of 0.04738 indicates the accuracy of the model, while the highly significant F-change ($p < 0.001$) confirms the robustness of its predictors/independent variables. Model 2, using broader predictors, such as overall IEQ perception and guest comfort, with slightly less precision (standard error = 0.12360). Both models exhibit no significant autocorrelation issues, where the Durbin values are 1.684 and 1.640 for Model 1 and Model 2, respectively. These results emphasize the importance of IEQ and its components in shaping the satisfaction of hotel guests in former GBI-certified green hotels.

Table 8 presents the results of ANOVA for Model 1 and Model 2, where it is revealed that for model 1, the regression model, including eight predictors/independent variables (IAQ, thermal comfort, lighting, visual or view, acoustic/noise, building characteristics, indoor decoration, and indoor greenery), significantly explains hotel guests' satisfaction ($F = 16{,}878.451$, $p < 0.001$). It is observed that the model approximately captures all the variance in satisfaction/dependent variable, with a regression sum of squares 303.085 out of a total of 303.927, leaving a negligible residual variance (0.842) and an exceptionally small mean square error (0.002). Therefore, it is suggested that the independent variables are highly effective in representing and explaining the satisfaction of the guest in former GBI-certified green hotel in Malaysian historical cities. This highlights the role of IEQ parameter in shaping the experiences of hotel guests. This emphasizes the importance of maintaining high standards in IAQ, thermal comfort, visual and acoustic elements, and aesthetic considerations to enhance satisfaction of hotel guests.

The ANOVA test results for Model 2 are also shown in Table 8. It is indicated that that the regression model, including only two predictors/independent variables, namely, overall IEQ-perception and hotel guests' comfort, significantly explains the satisfaction of hotel guests ($F = 9{,}756.144$, $p < 0.001$). The regression accounts for a substantial portion of the total variance, with a regression sum of squares of 298.106 out of a total of 303.927. However, the residual variance (5.821) and mean square error (0.015) are slightly higher compared to Model 1, indicating that while this simpler model is effective, it is less precise than the more

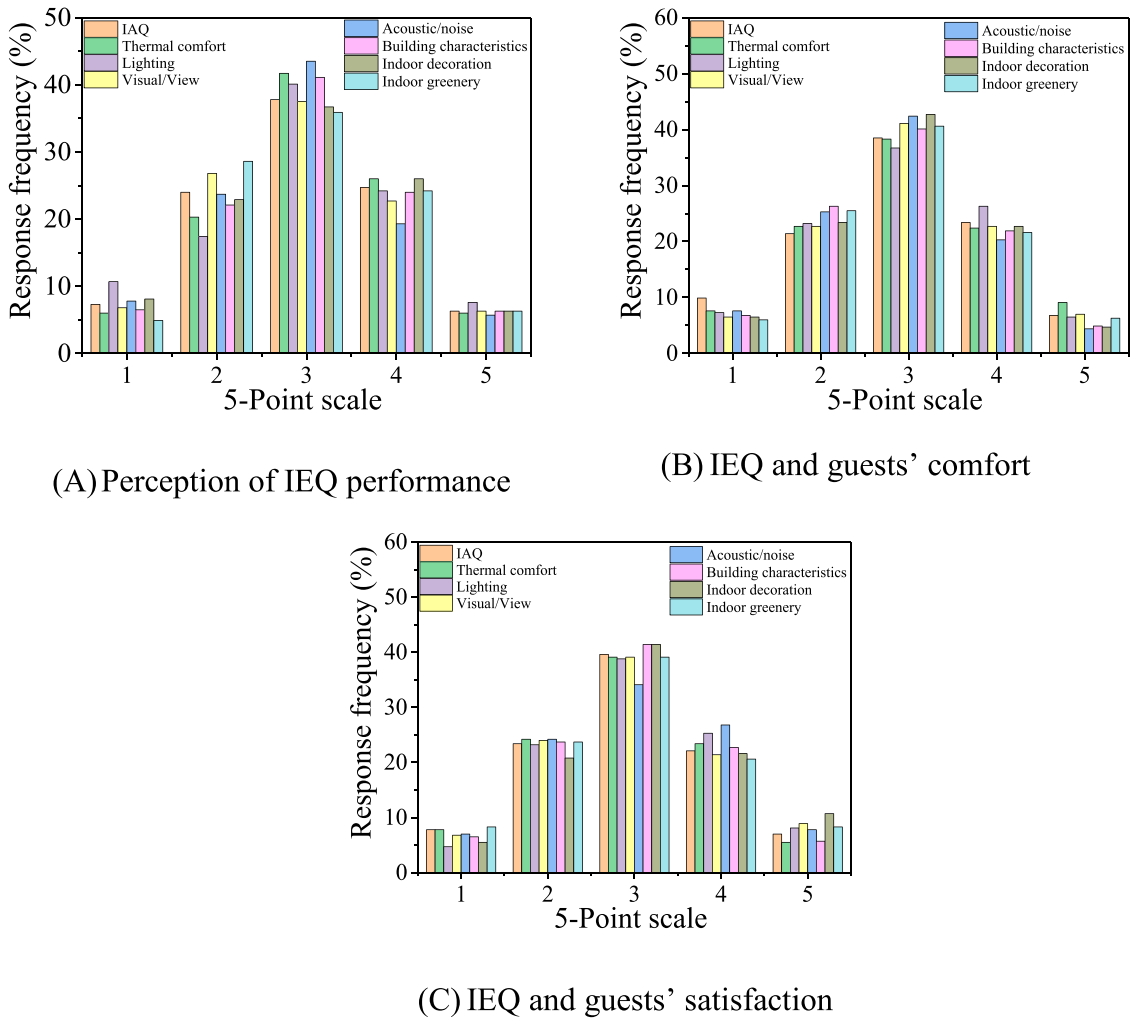

FIGURE 12
(A) Perception of IEQ performance. **(B)** IEQ and guests' comfort. **(C)** IEQ and guests' satisfaction. Response frequency (%) on perception, comfort, and satisfaction of IEQ parameters.

comprehensive Model 1. These findings demonstrate that IEQ perception and guest comfort are critical, overarching factors in predicting satisfaction of hotel guests in former GBI-certified green hotel, but additional environmental and design elements likely refine the explanation further.

Table 9 presents the regression coefficients of Model 1 and Model 2 for various predictors/independent variables of hotel guests' satisfaction. The model reveals how each IEQ parameter contributes to satisfaction. The constant (−0.212) suggests the baseline satisfaction when all predictors are zero. Among the predictors, acoustic/noise has the highest standardized coefficient (Beta = 0.305, $p < 0.001$), indicating it is the most significant factor influencing satisfaction. This is followed by IAQ (Beta = 0.221), Building characteristics (Beta = 0.167), and indoor decoration (Beta = 0.142), all with significant positive contributions ($p < 0.001$). Other factors, including thermal comfort (Beta = 0.116), indoor greenery (Beta = 0.124), lighting (Beta = 0.107), and visual comfort (VV) (Beta = 0.055) also show positive and statistically significant effects ($p < 0.001$).

The t-values further confirm the relative importance of these predictors/independent variables, with acoustic/noise (t = 16.904) and IAQ (t = 13.456) having the highest impact. Overall, the results emphasize that enhancing the IAQ, acoustic/noise, and building characteristics can significantly improve the satisfaction of guest in former GBI-certified green hotels. All predictors/independent variables are statistically significant ($p < 0.001$) and contribute positively, confirming the strong role of IEQ in shaping experiences of guest in in former GBI-certified green hotels in Malaysian historical cities.

5 Discussion and implications

In this study, it is confirmed that various IEQ parameters significantly impact guest comfort and satisfaction in former GBI-certified green hotels in Malaysian historical cities, as summarized in Table 10. Specifically, IAQ (B = 0.16), thermal comfort (B = 0.12), and acoustic/noise (B = 0.26) are the most

10.3389/fbuil.2025.1544177

TABLE 4 Descriptive statistics of IEQ factors, guests' comfort, and guests' satisfaction in former GBI-certified hotel.

Element	Mean	Std. Error of mean	Std. Deviation	Variance	Skewness	Kurtosis
IAQ	2.987	0.05182	1.01546	1.031	−0.034	−0.485
Thermal comfort	3.0573	0.04953	0.9705	0.942	−0.115	−0.285
Lighting	3.0052	0.0547	1.07182	1.149	−0.164	−0.448
Visual/View	2.9479	0.05143	1.00775	1.016	0.074	−0.479
Acoustic/Noice	2.9141	0.05017	0.9831	0.966	0.041	−0.225
Building Characteristics	3.013	0.05036	0.98677	0.974	−0.043	−0.334
Indoor Decoration	2.9948	0.05267	1.03211	1.065	−0.09	−0.529
Indoor greenery	2.9818	0.05049	0.98933	0.979	0.118	−0.55
Guests' Comfort-Mediator	2.9678	0.01737	0.34035	0.116	−0.273	0.080
Satisfaction	3.0146	0.01837	0.35994	0.13	−0.082	0.14

TABLE 5 Survey reliability analysis.

Item	Cronbach's alpha	No. of items
Indoor air Quality (IAQ)	0.86	14
Thermal Comfort	0.87	3
Lighting	0.75	5
Visual or View	—	—
Acoustic/Noise	0.78	2
Building Characteristics	0.83	5
Decoration and Indoor Greenery	0.82	3
IEQ and Comfort	0.94	7
IEQ and Satisfaction	0.94	7

impactful factors, with noise management identified as the most critical. Secondary parameters, including indoor lighting (B = 0.11), building characteristics (B = 0.14), indoor decoration (B = 0.11), visual comfort (B = 0.04), and indoor greenery (B = 0.10), also play meaningful roles, albeit to a lesser extent. The relatively lower impact of visual comfort (B = 0.04) and indoor greenery (B = 0.10) may be due to several factors. First, the specific design and layout of the hotels studied may have prioritized more critical IEQ factors, such as IAQ and thermal comfort, which tend to have a more immediate and noticeable effect on guest satisfaction. Second, the impact of visual comfort and indoor greenery may be influenced by contextual factors, such as the local climate, cultural preferences, and the architectural features of the historical hotels, which could have diminished the significance of these parameters. The significant relationship between IEQ and guest satisfaction (B = 0.52), as well as the mediating role of guest comfort (B = 0.53), underscores the importance of creating high-quality, comfortable indoor environments to enhance the overall guest experience in former GBI-certified green hotels in Malaysian historical cities.

These findings of this study offer practical insights for the hospitality industry, especially for green hotels in Malaysian historical cities. This study effectively bridges the gap between sustainability, health, and user experience by demonstrating how the key IEQ factors, such as air quality, thermal comfort, acoustics, and the presence of indoor vegetation, influence both guest comfort and satisfaction. By focusing on sustainable practices in former GBI-certified green hotels, the findings show that enhancing IEQ not only supports environmental sustainability but also promotes better health and a more enjoyable user experience. These insights can guide future hotel designs to integrate sustainable features that contribute to guest wellbeing and overall satisfaction. Hotel operators should prioritize key IEQ factors like air quality, thermal comfort, and noise management to meet guest expectations and boost satisfaction. Investments in air filtration systems, efficient temperature control, and noise reduction strategies are crucial. While factors such as visual comfort and greenery have a smaller impact, they remain important for a well-rounded guest experience. By balancing functionality and aesthetics, hotels can enhance guest loyalty and generate positive reviews. The study also introduces three new IEQ parameters, reflecting the evolving nature of green certification practices. This emphasizes the importance for hotel operators to stay updated on trends and innovations in sustainability and IEQ. Incorporating these parameters helps hotels meet modern guest expectations while maintaining their green certifications and competitiveness. Furthermore, guest comfort serves as a mediator between IEQ and satisfaction, underlining the need for thoughtful design and amenities to create an environment where guests feel both comfortable and at ease.

10.3389/fbuil.2025.1544177

TABLE 6 Correlation of IEQ parameters with guests' comfort and satisfaction using Spearman's rho.

Elements		IAQ	TC	Lighting	VV	AN	BC	ID	IG	IEQ	Comfort	Satisfaction
IAQ	Coefficient	1.000	0.895**	0.846**	0.873**	0.802**	0.960**	0.467**	0.470**	0.944**	0.967**	0.967**
	Sig		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Thermal Comfort (TC)	Coefficient	0.895**	1.000	0.778**	0.729**	0.608**	0.840**	0.343**	0.348**	0.821**	0.865**	0.842**
	Sig	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lighting	Coefficient	0.846**	0.778**	1.000	0.846**	0.794**	0.783**	0.520**	0.523**	0.907**	0.907**	0.907**
	Sig	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Visual comfort/ View (VV)	Coefficient	0.873**	0.729**	0.846**	1.000	0.625**	0.794**	0.665**	0.666**	0.891**	0.882**	0.872**
	Sig	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.000
Acoustic/ Noise (AC)	Coefficient	0.802**	0.608**	0.794**	0.625**	1.000	0.809**	0.119*	0.122*	0.789**	0.815**	0.852**
	Sig	0.000	0.000	0.000	0.000		0.000	0.020	0.017	0.000	0.000	0.000
Building characteristics (BC)	Coefficient	0.960**	0.840**	0.783**	0.794**	0.809**	1.000	0.397**	0.401**	0.902**	0.918**	0.938**
	Sig	0.000	0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Indoor decoration (ID)	Coefficient	0.467**	0.343**	0.520**	0.665**	0.119*	0.397**	1.000	0.979**	0.619**	0.556**	0.516**
	Sig	0.000	0.000	0.000	0.000	0.020	0.000		0.000	0.000	0.000	0.000
Indoor greenery (IG)	Coefficient	0.470**	0.348**	0.523**	0.666**	0.122*	0.401**	0.979**	1.000	0.622**	0.558**	0.519**
	Sig	0.000	0.000	0.000	0.000	0.017	0.000	0.000		0.000	0.000	0.000
Overall IEQ	Coefficient	0.944**	0.821**	0.907**	0.891**	0.789**	0.902**	0.619**	0.622**	1.000	0.989**	0.988**
	Sig	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000	0.000
Comfort - Mediator	Coefficient	0.967**	0.865**	0.907**	0.882**	0.815**	0.918**	0.556**	0.558**	0.989**	1.000	0.994**
	Sig	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		0.000
Satisfaction – Dependent variable	Coefficient	0.967**	0.842**	0.907**	0.872**	0.852**	0.938**	0.516**	0.519**	0.988**	0.994**	1.000
	Sig	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

TABLE 7 Summary of models.

Model Summary[a]										
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.999[b]	0.997	0.997	0.04738	0.997	16,878.451	8	375	0.000	1.684
2	0.990[c]	0.981	0.981	0.12360	0.981	9,756.144	2	381	0.000	1.640

[a]Dependent Variable: Hotel gests' satisfaction.
[b]Predictors: (Constant), IAQ, thermal comfort, lighting, visual or view, acoustic/noise, building characteristics, decoration, indoor greenery.
[c]Predictors: (Constant), IEQ, perception, hotel guests' comfort.

10.3389/fbuil.2025.1544177

TABLE 8 AROVA test results.

ANOVA[a]						
Model		Sum of Squares	Df	Mean Square	F	Sig
1[b]	Regression	303.085	8	37.886	16,878.451	0.000b
	Residual	0.842	375	0.002		
	Total	303.927	383			
2[c]	Regression	298.106	2	149.053	9,756.144	0.000[c]
	Residual	5.821	381	0.015		
	Total	303.927	383			

[a]Dependent Variable: Hotel gests' satisfaction.
[b]Predictors: (Constant), IAQ, thermal comfort, lighting, visual or view, acoustic/noise, building characteristics, decoration, indoor greenery.
[c]Predictors: (Constant), IEQ, perception, hotel guests' comfort.

TABLE 9 Coefficients table.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig
		B	Std. Error	Beta		
1[b]	(Constant)	−0.212	0.022		−9.720	0.000
	IAQ	0.161	0.012	0.221	13.456	0.000
	Thermal Comfort	0.119	0.017	0.116	7.169	0.000
	Lighting	0.109	0.016	0.107	6.966	0.000
	Visual comfort/View (VV)	0.044	0.009	0.055	4.777	0.000
	Acoustic/Noise (AC)	0.258	0.015	0.305	16.904	0.000
	Building characteristics (BC)	0.135	0.014	0.167	9.496	0.000
	Indoor decoration (ID)	0.112	0.009	0.142	12.293	0.000
	Indoor greenery (IG)	0.099	0.009	0.124	10.952	0.000
2[c]	(Constant)	−0.161	0.024		−6.656	0.000
	Hotel guests' comfort-mediator	0.516	0.036	0.484	14.376	0.000
	IEQ	0.532	0.035	0.511	15.176	0.000

[a]Dependent Variable: Hotel gests' satisfaction.
[b]Predictors: (Constant), IAQ, thermal comfort, lighting, visual or view, acoustic/noise, building characteristics, indoor decoration, indoor greenery.
[c]Predictors: (Constant), IEQ, perception, hotel guests' comfort.

Theoretically, the study confirms existing frameworks linking IEQ to guest satisfaction, while expanding them with new parameters. It provides valuable insights into the relationship between environmental quality, comfort, and satisfaction, particularly in culturally significant locations like Malaysian historical cities. However, the study's limitations include its focus on former GBI-certified green hotels in a specific region, which may limit the generalizability of its findings. Therefore, it is recommended that all hotels, especially in historic cities in Malaysia, enhance IEQ by improving air quality, thermal comfort, acoustics, and indoor greenery. Besides, hotels should focus on better ventilation, temperature control, noise reduction, and adding

TABLE 10 Test of Hypothesis.

ID	Hypotheses	B	Beta	Sig	
H1	IEQ parameters significantly influence green hotel guests' comfort and satisfaction in Malaysian historical cities	—	—	—	
H1a	Indoor air quality (IAQ) significantly influences green hotel guests' comfort and satisfaction in former GBI-certified green hotels located in Malaysian historical cities	0.16	0.16	0.16	Accepted
H1b	Indoor thermal comfort (TC) significantly influences green hotel guests' comfort and satisfaction in former GBI-certified green hotels located in Malaysian historical cities	0.12	0.12	0.12	Accepted
H1c	Indoor lighting significantly influences green hotel guests' comfort and satisfaction in former GBI-certified green hotels located in Malaysian historical cities	0.11	0.11	0.11	Accepted
H1d	Indoor visual comfort or view (VV) significantly influences green hotel guests' comfort and satisfaction in former GBI-certified green hotels located in Malaysian historical cities	0.04	0.04	0.04	Accepted
H1e	Indoor acoustic/noise (AN) significantly influences green hotel guests' comfort and satisfaction in former GBI-certified green hotels located in Malaysian historical cities	0.26	0.26	0.26	Accepted
H1f	Building characteristics significantly influences green hotel guests' comfort and satisfaction in former GBI-certified green hotels located in Malaysian historical cities	0.14	0.14	0.14	Accepted
H1g	Indoor decoration significantly influences green hotel guests' comfort and satisfaction in former GBI-certified green hotels located in Malaysian historical cities	0.11	0.11	0.11	Accepted
H1h	Indoor greenery significantly influences green hotel guests' comfort and satisfaction in former GBI-certified green hotels located in Malaysian historical cities	0.10	0.10	0.10	Accepted
H2	There is a significant relationship between the comfort and satisfaction of green hotel guests and the IEQ in former GBI-certified green hotels located in Malaysian historical cities	0.52	0.52	0.52	Accepted
H3	Guest comfort mediates the relationship between guest satisfaction and IEQ in former GBI-certified green hotels located in Malaysian historical cities	0.53	0.53	0.53	Accepted

indoor plants. Additionally, reliance on self-reported data may introduce response biases. Future research should consider mixed methods or objective measurements to build a more comprehensive understanding of IEQ's role in hospitality and contribute to the development of globally applicable standards.

6 Conclusion, recommendations, and future research directions

This study aimed to investigate the influence of IEQ parameters on guest comfort and satisfaction in former GBI-certified green hotels located in Malaysian historical cities. Using a structured survey methodology, data were collected from 700 respondents through paper-based and online questionnaires. After excluding incomplete responses, 384 valid questionnaires were retained, yielding a response rate of 54.9%, sufficient for robust statistical analysis. The study examined eight key IEQ parameters: IAQ, Thermal Comfort, Lighting, Visual Comfort, Acoustic/Noise, Building Characteristics, Indoor Decoration, and Indoor Greenery. Results revealed that Acoustic/Noise (B = 0.26), IAQ (B = 0.16), and Thermal Comfort (B = 0.12) were the most influential factors on guest satisfaction, with Lighting (B = 0.11), Visual Comfort (B = 0.04), and Indoor Greenery (B = 0.10) providing complementary contributions. The findings also validated the mediating role of guest comfort, with a strong direct correlation to satisfaction (r = 0.994), underscoring its amplifying effect on the relationship between IEQ and guest satisfaction. This study highlights the critical importance of optimizing IEQ parameters, particularly in noise management, air filtration, and temperature regulation, to enhance guest comfort and satisfaction. The insights contribute to existing theoretical frameworks by emphasizing the mediating role of comfort, while also providing practical recommendations for improving IEQ in hospitality settings, ensuring sustainability, and maintaining competitiveness.

Based on the finding of this study, it is recommended that GBI-certified green hotels in historic Malaysian cities prioritize optimizing key IEQ factors to enhance guest comfort. Specifically, hotels should focus on improving acoustics, IAQ, and temperature regulation, as these significantly influence guest satisfaction. Besides, effective lighting, visual comfort, and indoor greenery should be integrated, with guests given control over environmental settings. Additionally, this study on former GBI-certified green hotels in Malaysia emphasizes the importance for hotel operators to prioritize guest comfort and satisfaction by maintaining optimal IEQ. This can be achieved through regular guest feedback, which will refine sustainable practices and ensure both comfort and service quality are consistently upheld. Promoting the green certification through visible sustainability practices and conducting regular post-occupancy evaluations will ensure continuous improvement and alignment with guest preferences and satisfaction.

Despite the significance of this study, it has some limitations. First, relying on self-reported survey responses introduces the potential for biases, such as social desirability or response tendencies. However, these biases were mitigated through strategies like ensuring anonymity, neutral question phrasing, and reliability testing, which demonstrated high internal consistency in the responses. Second, the geographic scope was limited to Malaysia's historical cities, potentially restricting the generalizability of the findings to other cultural or climatic contexts. Future research should address these limitations by incorporating objective measurement methods and broadening the scope to include diverse geographic, cultural, and environmental settings, thereby validating and enhancing the broader applicability of the findings.

Moreover, future research should investigate the impact of emerging IAQ parameters, such as biophilic design and smart technologies, on guest experiences. Additionally, employing longitudinal studies and mixed methods, such as interviews and focus groups, could provide deeper insights into guest perceptions and the long-term impacts of IEQ. Comparative studies of certified, non-certified, and previously certified hotels could also offer valuable insights into the challenges and benefits of green certifications. Furthermore, research on demographic influences and cross-industry comparisons—such as those involving hospitality, healthcare, and office environments—could help refine IEQ standards and advance sustainable practices across sectors. Finally, exploring interaction effects among IEQ factors and employing advanced modeling approaches would further enrich the understanding of their complex relationships with guest satisfaction.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the (patients/participants OR patients/participants legal guardian/next of kin) was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

HA: Conceptualization, Investigation, Methodology, Software, Writing–original draft. IU: Resources, Supervision, Validation, Writing–review and editing. MA: Resources, Validation, Writing–review and editing. SA: Software, Validation, Writing–review and editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fbuil.2025.1544177/full#supplementary-material

References

Abdulaali, H. S., Hanafiah, M. M., Usman, I. M. S., Nizam, N. U. M., and Aljaberi, M. J. (2020b). A review on green hotel rating tools, indoor environmental quality (IEQ) and human comfort. *Int. J. Adv. Sci. Technol.* 29 (3), 128–157.

Abdulaali, H. S., Usman, I. M. S., and Alqawzai, S. (2024). Relationship between indoor environmental quality and guests' comfort and satisfaction at green hotels: a comprehensive review. *Open Eng.* 14 (1). doi:10.1515/eng-2024-0042

Abdulaali, H. S., Usman, I. M. S., Hanafiah, M., Aljaberi, M. J., Talib, M., and Nazal, A. A. (2020c). Impact of poor indoor environmental quality (IEQ) to inhabitants' health, wellbeing and satisfaction. *Int. J. Adv. Sci. Technol.* 29 (3), 1–14.

Abdulaali, H. S., Usman, I. M. S., Hanafiah, M. M., Aljaberi, M. J., and Basung, J. E. (2020a). *Online review analysis of perceived Indoor Environmental Quality (IEQ) at former green certified hotels in Kuala Lumpur, Malaysia*. China: Journal of Xi'an University of Architecture and Technology, 659–670.

Abri, EEWH (2009). *Green building evaluation system of Taiwan*. Taipei, Taiwan.

Akar-Ghibril, N., and Phipatanakul, W. (2020). The indoor environment and childhood asthma. *Curr. Allergy Asthma Rep.* 20 (9), 43. doi:10.1007/s11882-020-00941-5

Al horr, Y., Arif, M., Katafygiotou, M., Mazroei, A., Kaushik, A., and Elsarrag, E. (2016). Impact of indoor environmental quality on occupant well-being and comfort: a review of the literature. *Int. J. Sustain. Built Environ.* 5 (1), 1–11. doi:10.1016/j.ijsbe.2016.03.006

Allen, J. G., MacNaughton, P., Laurent, J. G. C., Flanigan, S. S., Eitland, E. S., and Spengler, J. D. (2015). Green buildings and health. *Curr. Environ. Health Rep.* 2 (3), 250–258. doi:10.1007/s40572-015-0063-y

Ariffin, A. A. M., and Aziz, N. A. (2012). The effect of physical environment's innovativeness onthe relationship between hosting quality and satisfactionin hotel services. *Int. J. Trade, Econ. Finance*, 337–342. doi:10.7763/ijtef.2012.v3.223

Ariffin, A. A. M., Maghzi, A., Soon, J. L. M., and Alam, S. S. (2018). Exploring the influence of hospitality on guest satisfaction in luxury hotel services. *e-Review Tour. Res.* 15 (1), 1–20.

Arsad, F. S., Hod, R., Ahmad, N., Baharom, M., and Ja'afar, M. H. (2023). Assessment of indoor thermal comfort temperature and related behavioural adaptations: a systematic review. *Environ. Sci. Pollut. Res.* 30 (29), 73137–73149. doi:10.1007/s11356-023-27089-9

Asadi, E., Costa, J. J., and Gameiro da Silva, M. (2011). Indoor air quality audit implementation in a hotel building in Portugal. *Build. Environ.* 46 (8), 1617–1623. doi:10.1016/j.buildenv.2011.01.027

ASHRAE (2015). Thermal environmental conditions for human occupancy.

Baliatsas, C., van Kamp, I., van Poll, R., and Yzermans, J. (2016). Health effects from low-frequency noise and infrasound in the general population: is it time to listen? A systematic review of observational studies. *Sci. Total Environ.* 557-558, 163–169. doi:10.1016/j.scitotenv.2016.03.065

Bedrosian, T. A., and Nelson, R. J. (2017). Timing of light exposure affects mood and brain circuits. *Transl. Psychiatry* 7 (1), e1017. doi:10.1038/tp.2016.262

Berezan, O., Raab, C., Yoo, M., and Love, C. (2013). Sustainable hotel practices and nationality: the impact on guest satisfaction and guest intention to return. *Int. J. Hosp. Manag.* 34, 227–233. doi:10.1016/j.ijhm.2013.03.010

Borowski, M., Zwolińska, K., and Czerwiński, M. (2022). An experimental study of thermal comfort and indoor air quality—a case study of a hotel building. *Energies (Basel)* 15 (6), 2026. doi:10.3390/en15062026

Bortolini, R., and Forcada, N. (2021). Association between building characteristics and indoor environmental quality through post-occupancy evaluation. *Energies (Basel)* 14 (6), 1659. doi:10.3390/en14061659

Boyce, P. (2014). *Human factors in lighting*. third edition. Florida, United States: CRC Press.

Buso, T., Dell'Anna, F., Becchio, C., Bottero, M. C., and Corgnati, S. P. (2017). Of comfort and cost: examining indoor comfort conditions and guests' valuations in Italian hotel rooms. *Energy Res. Soc. Sci.* 32, 94–111. doi:10.1016/j.erss.2017.01.006

Canha, N., Martinho, M., Silva, M. A., Almeida, S. M., Pegas, P., Alves, C., et al. (2012). Indoor air quality in primary schools. *Int. J. Environ. Pollut.* 50 (1/2/3/4), 396. doi:10.1504/ijep.2012.051210

Catalina, T., and Iordache, V. (2012). IEQ assessment on schools in the design stage. *Build. Environ.* 49, 129–140. doi:10.1016/j.buildenv.2011.09.014

Chang, T. Y., and Lin, Y. C. (2022). The effects of atmosphere on perceived values and customer satisfaction toward the theme hotel: the moderating role of green practice perception. *Sustainability* 14 (15), 9153. doi:10.3390/su14159153

Claudi, L., Arnesano, M., Chiariotti, P., Battista, G., and Revel, G. M. (2019). A soft-sensing approach for the evaluation of the acoustic comfort due to building envelope protection against external noise. *Measurement* 146, 675–688. doi:10.1016/j.measurement.2019.07.003

Creswell, J. W., and Creswell, J. D. (2017). *Research design: qualitative, quantitative, and mixed methods approach*. Fifth Edition. California, United States: SAGE Publications.

Dang, V. T., Nguyen, N., and Wang, J. (2021). The impact of retailers' indoor environmental quality on consumer purchase decision. *Int. J. Retail and Distribution Manag.* 49 (6), 772–794. doi:10.1108/ijrdm-04-2020-0130

Das, G., and Varshneya, G. (2017). Consumer emotions: determinants and outcomes in a shopping mall. *J. Retail. Consumer Serv.* 38, 177–185. doi:10.1016/j.jretconser.2017.06.008

Dattalo, P. (2008). *Determining sample size*. Oxford University Press.

Devitofrancesco, A., Belussi, L., Meroni, I., and Scamoni, F. (2019). Development of an indoor environmental quality assessment tool for the rating of offices in real working conditions. *Sustainability* 11 (6), 1645. doi:10.3390/su11061645

Dong, X., Wu, Y., Chen, X., Li, H., Cao, B., Zhang, X., et al. (2021). Effect of thermal, acoustic, and lighting environment in underground space on human comfort and work efficiency: a review. *Sci. Total Environ.* 786, 147537. doi:10.1016/j.scitotenv.2021.147537

EPA (2022). Available at: https://www.epa.gov/. Washington, D.C., United State: United States Environmental Protection Agency.

Esfandiari, M., Mohamed, Z. S., Ismail, M. A., Reza Hafezi, M., Asadi, I., Mohammadi, S., et al. (2021). Occupants' satisfaction toward indoor environment quality of platinum green-certified office buildings in tropical climate. *Energies (Basel)* 14 (8), 2264. doi:10.3390/en14082264

Fernandez-Antolin, M. M., del Río, J. M., and Gonzalez-Lezcano, R. A. (2022). Building performance simulation tools as part of architectural design: breaking the gap through software simulation. *Int. J. Technol. Des. Educ.* 32 (2), 1227–1245. doi:10.1007/s10798-020-09641-7

Fossgard, K., and Fredman, P. (2019). Dimensions in the nature-based tourism experiencescape: an explorative analysis. *J. Outdoor Recreat. Tour.* 28, 100219. doi:10.1016/j.jort.2019.04.001

Fraga, S., Ramos, E., Martins, A., João Samúdio, M., Silva, G., Guedes, J., et al. (2008). Indoor air quality and respiratory symptoms in Porto schools. *Rev. Port. Pneumol.* 14 (4), 487–507. doi:10.1016/s2173-5115(08)70277-x

Gao, Y., and Mattila, A. S. (2014). Improving consumer satisfaction in green hotels: the roles of perceived warmth, perceived competence, and CSR motive. *Int. J. Hosp. Manag.* 42, 20–31. doi:10.1016/j.ijhm.2014.06.003

Garaus, M., Wagner, U., and Manzinger, S. (2017). Happy grocery shopper: the creation of positive emotions through affective digital signage content. *Technol. Forecast Soc. Change* 124, 295–305. doi:10.1016/j.techfore.2016.09.031

Gayathri, L., and Pb, S. D. (2016). "Factors affecting the indoor environmental quality in Sri Lanka: green vs. Conventional hotel buildings," in *The 5th world construction symposium*, 210–220.

GBI (2022). Malaysia's Greenbuildingindex.

Han, H., Jongsik, Y., and Hyun, S. S. (2020). Nature based solutions and customer retention strategy: eliciting customer well-being experiences and self-rated mental health. *Int. J. Hosp. Manag.* 86, 102446. doi:10.1016/j.ijhm.2019.102446

Hu, X., and Dang-Van, T. (2023). Emotional and behavioral responses of consumers toward the indoor environmental quality of green luxury hotels. *J. Hosp. Tour. Manag.* 55, 248–258. doi:10.1016/j.jhtm.2023.04.009

Hua, Y., Göçer, Ö., and Göçer, K. (2014). Spatial mapping of occupant satisfaction and indoor environment quality in a LEED platinum campus building. *Build. Environ.* 79, 124–137. doi:10.1016/j.buildenv.2014.04.029

Huang, L., Zhu, Y., Ouyang, Q., and Cao, B. (2012). A study on the effects of thermal, luminous, and acoustic environments on indoor environmental comfort in offices. *Build. Environ.* 49, 304–309. doi:10.1016/j.buildenv.2011.07.022

Huiberts, L. M., Smolders, KCHJ, and de Kort, Y. A. W. (2016). Non-image forming effects of illuminance level: exploring parallel effects on physiological arousal and task performance. *Physiol. Behav.* 164, 129–139. doi:10.1016/j.physbeh.2016.05.035

Hwang, T., and Jeong, T. K. (2011). Effects of indoor lighting on occupants' visual comfort and eye health in a green building. *Indoor Built Environ.* 20 (1), 75–90. doi:10.1177/1420326x10392017

Jafari, M. J., Khosrowabadi, R., Khodakarim, S., and Mohammadian, F. (2019). The effect of noise exposure on cognitive performance and brain activity patterns. *Open Access Maced. J. Med. Sci.* 7 (17), 2924–2931. doi:10.3889/oamjms.2019.742

Jin, Q. (2017). The indoor environmental quality improving and energy saving potential of phase-change material integrated facades for high-rise office buildings in shanghai. *Int. J. High-Rise Build.* 6 (2), 197–205. doi:10.21022/ijhrb.2017.6.2.197

Kharvari, F., and Rostami-Moez, M. (2021). Assessment of occupant adaptive behavior and visual comfort in educational facilities: a cross-sectional field survey. *Energy Sustain. Dev.* 61, 153–167. doi:10.1016/j.esd.2021.02.001

Kim, A., Wang, S., McCunn, L., Prozuments, A., Swanson, T., and Lokan, K. (2019a). Commissioning the acoustical performance of an open office space following the latest healthy building standard: a case study. *Acoustics* 1 (3), 473–492. doi:10.3390/acoustics1030027

Kim, J., Hong, T., Lee, M., and Jeong, K. (2019b). Analyzing the real-time indoor environmental quality factors considering the influence of the building occupants' behaviors and the ventilation. *Build. Environ.* 156, 99–109. doi:10.1016/j.buildenv.2019.04.003

Kim, M., Lee, E., Kim, S. J., Cha, J., and Cichy, R. F. (2023). Impact of indoor environmental quality on hotel guests' behaviors. *Int. J. Hosp. and Tour. Adm.* 24 (2), 288–313. doi:10.1080/15256480.2021.1981188

Kuo, N. W., Chiang, H. C., and Chiang, C. M. (2008). Development and application of an integrated indoor air quality audit to an international hotel building in Taiwan. *Environ. Monit. Assess.* 147 (1–3), 139–147. doi:10.1007/s10661-007-0105-5

Kwong, Q. J. (2020). Light level, visual comfort and lighting energy savings potential in a green-certified high-rise building. *J. Build. Eng.* 29, 101198. doi:10.1016/j.jobe.2020.101198

Lam, L. W., Chan, K. W., Fong, D., and Lo, F. (2011). Does the look matter? The impact of casino servicescape on gaming customer satisfaction, intention to revisit, and desire to stay. *Int. J. Hosp. Manag.* 30 (3), 558–567. doi:10.1016/j.ijhm.2010.10.003

Laquatra, J., Pillai, G., Singh, A., and Syal, M. G. (2008). Green and healthy housing. *J. Archit. Eng.* 14 (4), 94–97. doi:10.1061/(asce)1076-0431(2008)14:4(94)

Lee, J., Wargocki, P., Chan, Y., Chen, L., and Tham, K. (2019). Indoor environmental quality, occupant satisfaction, and acute building-related health symptoms in Green Mark-certified compared with non-certified office buildings. *Indoor Air* 29 (1), 112–129. doi:10.1111/ina.12515

LEED (2018). Available at: https://www.usgbc.org/articles/green-building-101-what-indoor-environmental-quality.*Green Building 101: what is indoor environmental quality?*.

Liu, X., Sun, Y., Wei, S., Meng, L., and Cao, G. (2021). Illumination distribution and daylight glare evaluation within different windows for comfortable lighting. *Results Opt.* 3, 100080. doi:10.1016/j.rio.2021.100080

Lu, M., Hu, S., Mao, Z., Liang, P., Xin, S., and Guan, H. (2020). Research on work efficiency and light comfort based on EEG evaluation method. *Build. Environ.* 183, 107122. doi:10.1016/j.buildenv.2020.107122

Mallawaarachchi, H., De Silva, L., and Rameezdeen, R. (2016). Indoor environmental quality and occupants' productivity Suggestions to enhance national green certification criteria. *Built Environ. Proj. Asset Manag.* 6 (5), 462–477. doi:10.1108/bepam-09-2015-0046

Mamani, T., Herrera, R. F., Muñoz-La Rivera, F., and Atencio, E. (2022). Variables that affect thermal comfort and its measuring instruments: a systematic review. *Sustainability* 14 (3), 1773. doi:10.3390/su14031773

Maula, H., Hongisto, V., Östman, L., Haapakangas, A., Koskela, H., and Hyönä, J. (2016). The effect of slightly warm temperature on work performance and comfort in open-plan offices - a laboratory study. *Indoor Air* 26 (2), 286–297. doi:10.1111/ina.12209

Mohammed, A., and Rashid, B. (2018). A conceptual model of corporate social responsibility dimensions, brand image, and customer satisfaction in Malaysian hotel industry. *Kasetsart J. Soc. Sci.* 39 (2), 358–364. doi:10.1016/j.kjss.2018.04.001

Moya, T. A., van den Dobbelsteen, A., Ottelé, M., and Bluyssen, P. M. (2019). A review of green systems within the indoor environment. *Indoor Built Environ.* 28 (3), 298–309. doi:10.1177/1420326x18783042

Mujan, I., Anđelković, A. S., Munćan, V., Kljajić, M., and Ružić, D. (2019). Influence of indoor environmental quality on human health and productivity - a review. *J. Clean. Prod.* 217, 646–657. doi:10.1016/j.jclepro.2019.01.307

Nowicka, E. (2020). The acoustical assessment of the commercial spaces and buildings. *Appl. Acoust.* 169, 107491. doi:10.1016/j.apacoust.2020.107491

Okamoto-Mizuno, K., and Mizuno, K. (2012). Effects of thermal environment on sleep and circadian rhythm. *J. Physiol. Anthropol.* 31 (1), 14. doi:10.1186/1880-6805-31-14

Olesen, B. W. (2007). The philosophy behind EN15251: indoor environmental criteria for design and calculation of energy performance of buildings. *Energy Build.* 39 (7), 740–749. doi:10.1016/j.enbuild.2007.02.011

Patnaik, A., Kumar, V., and Saha, P. (2018). Importance of indoor environmental quality in green buildings. 53–64. doi:10.1007/978-981-10-5792-2_5

Piasecki, M., Kostyrko, K., and Pykacz, S. (2017). Indoor environmental quality assessment: Part 1: choice of the indoor environmental quality sub-component models. *J. Build. Phys.* 41 (3), 264–289. doi:10.1177/1744259117702882

Preziosi, M., Acampora, A., Lucchetti, M. C., and Merli, R. (2022). Delighting hotel guests with sustainability: revamping importance-performance analysis in the light of the three-factor theory of customer satisfaction. *Sustainability* 14 (6), 3575. doi:10.3390/su14063575

Qi, M., Li, X., Zhu, E., and Shi, Y. (2017). Evaluation of perceived indoor environmental quality of five-star hotels in China: an application of online review analysis. *Build. Environ.* 111, 1–9. doi:10.1016/j.buildenv.2016.09.027

Rahmiati, F., Dewi, PGLG, Othman, N. A., Madden, K., Advincula, G. B., and Sitorus, Y. (2024). Exploring the effect of guest experience on guest loyalty: mediating role of guest satisfaction. *J. Fokus Manaj. Bisnis* 14 (2), 177–189. doi:10.12928/fokus.v14i2.10526

Ramlee, N. A., Naveen, J., and Jawaid, M. (2021). Potential of oil palm empty fruit bunch (OPEFB) and sugarcane bagasse fibers for thermal insulation application – a review. *Constr. Build. Mater* 271, 121519. doi:10.1016/j.conbuildmat.2020.121519

Ravindu, S., Rameezdeen, R., Zuo, J., Zhou, Z., and Chandratilake, R. (2015). Indoor environment quality of green buildings: case study of an LEED platinum certified factory in a warm humid tropical climate. *Build. Environ.* 84, 105–113. doi:10.1016/j.buildenv.2014.11.001

Rhee, H. T., and Yang, S. B. (2015). How does hotel attribute importance vary among different travelers? An exploratory case study based on a conjoint analysis. *Electron. Mark.* 25 (3), 211–226. doi:10.1007/s12525-014-0161-y

Roelofsen, P. (2002). The impact of office environments on employee performance: the design of the workplace as a strategy for productivity enhancement. *J. Facil. Manag.* 1 (3), 247–264. doi:10.1108/14725960310807944

Saad, S. M., Shakaff, A. Y. M., Saad, A. R. M., Yusof, A. M., Andrew, A. M., Zakaria, A., et al. (2017). Development of indoor environmental index: air quality index and thermal comfort index. 020043.

Sahid, N., Rahim, R., Hamzah, B., and Mulyadi, R. (2019). Analysis of indoor thermal comfort of room space in the international standard hotel building. *Adv. Soc. Sci. Res. J.* 6 (2). doi:10.14738/assrj.62.6195

Sarkhosh, M., Najafpoor, A. A., Alidadi, H., Shamsara, J., Amiri, H., Andrea, T., et al. (2021). Indoor Air Quality associations with sick building syndrome: an application of decision tree technology. *Build. Environ.* 188, 107446. doi:10.1016/j.buildenv.2020.107446

Serghides, D. K., Chatzinikola, C. K., and Katafygiotou, M. C. (2015). Comparative studies of the occupants' behaviour in a university building during winter and summer time. *Int. J. Sustain. Energy* 34 (8), 528–551. doi:10.1080/14786451.2014.905578

Shan, M., and Hwang, B. (2018). Green building rating systems: global reviews of practices and research efforts. *Sustain Cities Soc.* 39, 172–180. doi:10.1016/j.scs.2018.02.034

Sharif, S., Kamaruzzaman, S. N., and Pitt, M. (2016). Implementation framework of green building for Malaysian government building: KKR2 study. *MATEC Web Conf.* ;66:00095, doi:10.1051/matecconf/20166600095

Shen, Z., Yang, X., Liu, C., and Li, J. (2021). Assessment of indoor environmental quality in budget hotels using text-mining method: case study of top five brands in China. *Sustainability* 13 (8), 4490. doi:10.3390/su13084490

Solomon, M. R. (2018). *Consumer behavior: buying, having and being*. Sixth edition. New York: Pearson.

Suhag, U., and Maan, S. (2022). Exploring the perception of the green hotel guests towards green practices. *IOSR J. Bus. Manag. (IOSR-JBM)* 24 (7), 20–29.

Sun, B., Liu, L. Y., Chan, W. W., Zhang, C. X., and Chen, X. (2021). Signals of hotel effort on enhancing IAQ and booking intention: effect of customer's body mass index associated with sustainable marketing in tourism. *Sustainability* 13 (3), 1279. doi:10.3390/su13031279

Taherdoos, H. (2017). Determining sample size; how to calculate survey sample size. *Int. J. Econ. Manag. Syst.* 2, 237–239.

Tourism Malaysia (2013). Available at: http://mytourismdata.tourism.gov.my/.2023. MyTourismData.

Tsirigoti, D., Giarma, C., and Tsikaloudaki, K. (2020). Indoor acoustic comfort provided by an innovative preconstructed wall module: sound insulation performance analysis. *Sustainability* 12 (20), 8666. doi:10.3390/su12208666

Turunen, M., Toyinbo, O., Putus, T., Nevalainen, A., Shaughnessy, R., and Haverinen-Shaughnessy, U. (2014). Indoor environmental quality in school buildings, and the health and wellbeing of students. *Int. J. Hyg. Environ. Health* 217 (7), 733–739. doi:10.1016/j.ijheh.2014.03.002

Wei, W., Lu, J. G., Galinsky, A. D., Wu, H., Gosling, S. D., Rentfrow, P. J., et al. (2017). Regional ambient temperature is associated with human personality. *Nat. Hum. Behav.* 1 (12), 890–895. doi:10.1038/s41562-017-0240-0

Wei, W., Wargocki, P., Zirngibl, J., Bendžalová, J., and Mandin, C. (2020). Review of parameters used to assess the quality of the indoor environment in Green Building certification schemes for offices and hotels. *Energy Build.* 209, 109683. doi:10.1016/j.enbuild.2019.109683

Wirz-Justice, A., Skene, D. J., and Münch, M. (2021). The relevance of daylight for humans. *Biochem. Pharmacol.* 191, 114304. doi:10.1016/j.bcp.2020.114304

Wu, P., Fang, Z., Luo, H., Zheng, Z., Zhu, K., Yang, Y., et al. (2021). Comparative analysis of indoor air quality in green office buildings of varying star levels based on the grey method. *Build. Environ.* 195, 107690. doi:10.1016/j.buildenv.2021.107690

Xiao, H., Cai, H., and Li, X. (2021). Non-visual effects of indoor light environment on humans: a review. *Physiol. Behav.* 228, 113195. doi:10.1016/j.physbeh.2020.113195

Xiao, L., Wu, R., Huang, J., Yang, X., and Xu, A. (2022). Study on the relationship between restoration benefit and visual satisfaction of LONG-PLAN's indoor vertical greenery. *Buildings* 12 (8), 1267. doi:10.3390/buildings12081267

Xu, J., Li, M., Huang, D., Wei, Y., and Zhong, S. (2022). A comparative study on the influence of different decoration styles on subjective evaluation of hotel indoor environment. *Buildings* 12 (11), 1777. doi:10.3390/buildings12111777

Yao, M., and Zhao, B. (2017). Window opening behavior of occupants in residential buildings in Beijing. *Build. Environ.* 124, 441–449. doi:10.1016/j.buildenv.2017.08.035

Zareh, N., Nassar, M., Barakat, M., and Ramzy, Y. (2023). Impact of green practices on hotel guests' satisfaction: the role of perceived motives, attributes, and service outcomes. *Pharos Int. J. Tour. Hosp.* 1 (2), 1–17. doi:10.21608/pijth.2023.287371

Zhang, L., Wu, J., Liu, H., and Zhang, X. (2020). The value of going green in the hotel industry: evidence from beijing. *Real Estate Econ.* 48 (1), 174–199. doi:10.1111/1540-6229.12225