

Review Article

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Relationship between indoor environmental quality and guests' comfort and satisfaction at green hotels: A comprehensive review

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Abstract: Recent studies have focused on different aspects of green management, practices, and green consumption in the hotel industry. However, there is a need to explore and better understand the association between indoor environmental quality (IEQ) and green hotel guest's comfort. Therefore, it is essential to explore the effects of IEQ on the comfort and satisfaction of green hotel guests. This study conducts a comprehensive review of the effects of various IEQ parameters, including indoor air quality, thermal comfort, lighting, visual/view, acoustic comfort, building characteristics, decoration, and indoor greenery, on guest's comfort and satisfaction in green hotels. Based on previous literature, it was also revealed that most current green building schemes lack of comprehensive evaluation of the performance of IEQ dimensions in green hotels. It was also observed that these IEQ parameters show a significant influence on the hotel guest's comfort and satisfaction. Based on the findings of the literature review, a conceptual model was developed to represent the relationship between the IEQ parameters and guest's comfort and satisfaction. The proposed conceptual model can be implemented by the hotel management for a comprehensive assessment of guests' perceptions toward the IEQ in green hotels. The novelty of this study is based on its findings that establish a more effective IEQ evaluation method and serve as the reference scenario of IEQ, which

can be a useful tool for both academicians and practitioners and contribute to improving the indoor environmental performance of green hotels through highlighting the key IEQ parameters, which affect the comfort and satisfaction of hotel guests.

Keywords: comfort, green hotels, green building schemes, hotel guest, indoor environmental quality, satisfaction

1 Introduction

The hospitality industry significantly contributes to the socio-economic sector. Still, its operations industry operates in an environment that requires excessive consumption of natural resources [1], resulting in environmental degradation, pollution, and depletion of resources in the future. The hospital industry has rapidly expanded, and hotel buildings are required to accommodate tourism activities [2]. Hotel buildings are considered an essential part of the lodging sector [3], which is responsible for socio-environmental tourism damage in two phases: construction and operation phases. Unplanned, uncontrolled, and rapid hotel construction can produce dust, runoffs, and debris that contribute to the contamination of the surrounding air, water, and environment. It simultaneously affects the surrounding nature and causes further deterioration during the operation phase. Green building (GB) and green hotel rating tools have been developed around the world in an attempt to operate the hotels in a more sustainable and efficient manner, ensuring human comfort and satisfaction within indoor areas.

Indoor environmental quality (IEQ) is essential for the human's health and well-being [4]. It is especially relevant due to the high percentage of time spent indoors by the average person [5,6]. IEQ is one of the main elements of the GB schemes because it is essential for achieving the comfort and satisfaction of occupants. It plays a crucial role in evaluating the satisfaction and comfort. It was stated that the IEQ basically consists of five parameters including

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indoor air quality (IAQ), thermal comfort, lighting, visual or view, and acoustic or noise. These factors are important for the green assessment criteria in evaluating the occupant's comfort [7]. Positive IEQ can enhance the comfort and well-being of occupants by inducing positive perceptual results. Uncomfortable IEQ, such as inappropriate temperature, humidity level, noise level, poor lighting [8,9], poor IAQ, and bad smells [10,11], can significantly impede life quality and conversely influence the experience of hotel occupants [12,13]. In addition, long-term exposure to unpleasant indoor environments can cause adverse changes in the health conditions of inhabitants. To ensure proper indoor environment for hotel guest's inhabitants, the evaluation of IEQ has been introduced in recent years.

In the hotel industry, IEQ has become an important indicator that influences customer satisfaction [13]. Besides, it was also reported that the comfort of the building's occupants is significantly influenced by other performance indicators, such as building characteristics, decoration, indoor greenery, furniture and furnishing, cleaning and maintenance, and privacy [7,14]. Previous studies have mainly focused on the IEQ in offices [15,16], residential buildings [17], and commercial hotels. For example, Devitofrancesco *et al.* [18] proposed an IEQ evaluation tool for offices based on measuring several IEQ parameters, such as thermal environment, IAQ, acoustic environment, and luminous environment. Piasecki *et al.* [19] proposed an IEQ index by measuring the dissatisfaction of building occupants with IEQ parameters, including air temperature and CO₂ concentration. Mui *et al.* [20] also developed an IEQ index consisting of five parameters, such as air temperature, relative humidity, CO₂ concentration, horizontal illumination level, and sound pressure level; the focus was on air-conditioned buildings. Suh *et al.* [21] examined the effects of IAQ, thermal environment, and acoustics on occupant satisfaction. Some studies have investigated the perception of IEQ by hotel guests, especially green hotel guests. For example, Li *et al.* [22] used these reviews to identify determinants of customer satisfaction in hospitality. Liu and Park [23] identified key factors affecting the perceived usefulness of online consumer reviews. Xie *et al.* [24] explored the relationship between online consumer reviews and offline hotel popularity. Buso *et al.* [26] also investigated the indoor comfort conditions and valuations of guests in Italian hotel rooms. Qi *et al.* [25] and Piasecki *et al.* [19] analyzed the IEQ issues in five-star hotels in China and South Korea. Shen *et al.* [27] assessed the IEQ in the top five brand hotels in China using the text-mining approach. Studies are also reported on the relationship between the IEQ parameters with hotel guest's comfort and satisfaction in Malaysian green hotels before and after its validity surpassed [28]. Nevertheless, comprehensive

systematic review studies have still not yet emerged. Therefore, there is still a lack of existing research that accounts for comprehensive IEQ parameters to determine the comfort and satisfaction of hotel guests staying in green hotel rooms, together with the considerable attention given to the concept of experience IEQ in the present competitive environment. Therefore, recognizing and understanding the customers' comfort and satisfaction with the IEQ of green hotels is essential for the sustainable development of the entire hotel industry. Accordingly, there is a need to delve in some of IEQ parameters to understand its correlations with the hotel guests' health, well-being and satisfaction.

Accordingly, the above-mentioned studies did not include a comprehensive description that presents the association between several IEQ parameters with the hotel guests' comfort and satisfaction based on a systematic review approach. To address this research gap and enrich the extant of literature, this study aims to provide insights into IEQ parameters and their influences on green hotels' guests' comfort and satisfaction. The novelty of this study is that it contributes to a more effective IEQ evaluation technique and serves as the reference scenario of IEQ to improve the indoor environment performance of green hotels by summarizing the most essential IEQ parameters, which affect the comfort and satisfaction of hotel guests. The main objectives of this study are listed as follows:

- (a) To provide an overview of the essential parameters that affect the IEQ in green hotel rooms.
- (b) To explore the potential relationship between IEQ parameters, including IAQ, thermal comfort, lightening, visual and acoustic, as well as building characteristics, decoration and indoor greenery, and comfort/satisfaction of guests at hotels using a systematic review procedure.
- (c) To summarize the existing literature on investigating the relationship between IEQ parameters and guests' comfort and satisfaction.
- (d) To propose a simple conceptual model, which can be implemented by the hotel management for a comprehensive assessment of guests' perceptions toward the IEQ in the green hotels.

2 Research methodology

In order to meet the aim of this study, a systematic review procedure was conducted in order to address the relationship between IEQ and guests' comfort and satisfaction in green hotels. It was stated that the systematic review approach is a research method that can be used to collect and synthesize all relevant research findings that fit the pre-defined inclusion criteria in order to address

particular research [29]. The systematic review method is conducted in four stages, namely (a) brainstorming, (b) database selection, (c) bibliometric search, and (d) sample refining and selection, as illustrated in Figure 1.

2.1 Brainstorming

Brainstorming is considered an effective way to define the boundary of IEQ in green hotel rooms and set the research objectives and questions. In this research, the boundary is lined by diverse topics on the effect of IEQ parameters on guests' comfort and satisfaction in green hotels. Brainstorming can help to generate various ideas, which can be consolidated into a group of topics that can form the boundary of IEQ research. The brainstorming group consisted of two PhD researchers, each with 3 to 6 years of research experience on various research topics. The brainstorming session was conducted via Zoom Meeting Mobile Apps on 1 September 2023 and lasted for 2 h. The aim of the brainstorming session was to explore the key research areas in the IEQ factor of green hotels research. The members of the group were informed about the aim of the brainstorming session ahead in order to improve its efficiency. The entire emerging ideas during the process of brainstorming were integrated into a large idea map with the assistance of the MindGenious graphical thinking software tool. Identical topics were consolidated.

2.2 Database selection

A number of databases such as Scopus, PubMed, Web of Science, and Google Scholar are currently available for indexing scientific papers. Some research has indicated that the Scopus database is preferred over other databases [30], because it is accurate in performance [31] and has been used extensively in review articles in the area of IEQ factors at green hotels [32,33]. However, other researchers have stated that the Web of Science is a comprehensive publications database in comparison with other databases [34]. Thus, both the Scopus database and the Web of Science database are considered in this study; meanwhile, Google Scholar is also used as an assistant tool.

2.3 Bibliometric search

For this purpose, “relationship between IEQ and guest's satisfaction and comfort at green hotel,” “indicators of

indoor environment assessment for visitors' satisfaction at green hotels,” and “assessment of IEQ at green hotels utilizing text-mining approach” as keywords in article titles, abstracts, and keywords is searched among articles and review papers from 2010 to 2023 in Google Scholar, Scopus, and Web of Science databases. The initial search generated lists of 50, 65, and 35 papers for the first, second, and third keywords, respectively, which were sorted by relevance in Scopus and Web of Science.

2.4 Sample refining and selection

In the refining, the titles, abstracts, and keywords of research papers were carefully checked and subsequent in-depth reading of the entire paper, the number of 38, 52, and 20 papers with the most relevant content is selected.

3 GB schemes

GB schemes are defined as tools for assessing the performance of buildings in relation to IEQ, efficiency of energy and water, IAQ, site, and environmental impacts [35,36]. The concept of the GB movement has been progressively grown throughout the years. Various GB schemes have been emerged in different countries to account for the difference in climate, people, and geographical importance without embracing the codes of GBs. Some of these GB schemes include GBI, LEEDS, BREEAM, GREEN MARK, GREEN STAR, CASBEE, *etc.* They have been emerged as a result of green initiatives introduced to suit each country [37]. It was claimed that there are approximately more than 600 GB schemes across the world [38]. These GB schemes aim to define GBs and encourage the design of GB as well as identify and appreciate the environmental initiatives that transform the buildings and minimize the damages to the environment [2,39]. According to Wei *et al.* [40], GB schemes aim to attain sustainable buildings that are healthy, energy efficient, and friendly to the environment.

GB schemes have widely emerged to promote the design and construction of buildings beyond the regulatory minimum requirements toward a green standard [41]. They serve as extensive approaches for assessing the recognition of the greenness level attained by a building [42]. The rapid growth of GB demands across the world acts as a forefront to provide the occupants of the building with a better indoor environment to ensure the health, comfort, and satisfaction of inhabitants as well as mitigating the

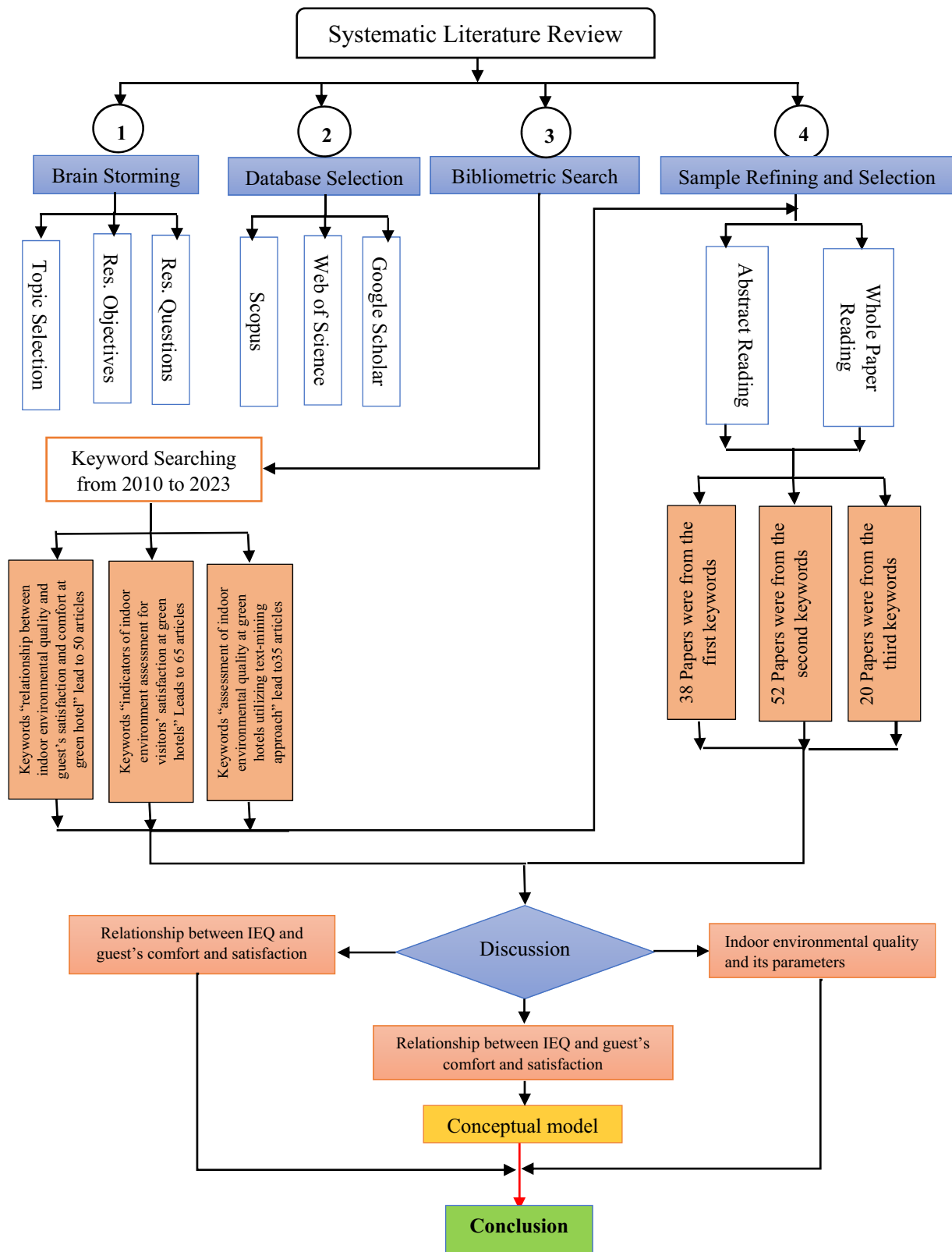


Figure 1: Research methodology.

climate change problems with advanced technologies that promote resource efficiency [43]. Besides the pre-existing GB schemes for GB ratings, there are some specific GB schemes for hotel buildings, where some examples are listed in Table 1.

4 IEQ and its parameters

IEQ is defined as the indoor space quality that is composed of several elements, such as IAQ, thermal comfort, acoustics, sound, odor, vibration, lighting, ergonomics, cleanliness, control, and maintenance [49]. These parameters concern the environmental conditions inside the building and their influence on the health, comfort, and satisfaction of occupants [48]. IEQ is generally evaluated using objective measurements, subjective surveys, and both [6]. It is one of the key components in evaluating the building to meet the attributes of GB. Besides, IEQ is an essential element for attaining the sustainability of a building due to its effect on the health, comfort, and satisfaction of inhabitants [44]. It documents the indoor environmental performance of buildings and its effects on the health and well-being of occupants [45]. IEQ is composed of several conditions within the interior environment of building [46]. According to Guida *et al.* [47], the indoor environment represents the confined environment of life and work offices, housing, social and or recreational facilities.

Numerous GB schemes have incorporated the IEQ component as one of the assessment criteria, and hence, it is expected that the GBs would be better and more comfortable to meet the occupant's satisfaction compared with the traditional buildings.

As summarized in Figure 2, the majority of GB schemes provide credits to four basic IEQ elements, such as IAQ, thermal comfort, acoustic comfort, and visual comfort, while KLIMA gives credits only to the IAQ and thermal comfort. The BREEAM and LEED GB certification schemes are the most famous international GB schemes [50]. In the BREEAM scheme, IEQ elements are provided under the section called “health and wellbeing” [51], while IEQ

elements in the LEED GB scheme are assessed under the section called “indoor environmental quality” [51]. The BREEAM allocates 18 points of 150 to IEQ, while LEED allocates 17 points out of 110 to IEQ. The BCA GMS allocates 43 scores out of 190 to IEQ. The allocations of other GB schemes for IEQ are summarized in Table 2.

Under the section of IEQ in the LEED scheme, IEQ comprises IAQ, tobacco smoke, CO₂ monitoring, indoor chemical sources and pollutants, daylight, thermal comfort, ventilation efficiency, and views [52]. A review of the credits assigned in BREEAM and Green Star GB schemes has indicated that approximately 10–20% of all scores that can be allocated to the various parameters certified by these GB schemes are related to IEQ [53,54]. GMS has different criteria applicable to new and existing buildings as well as to the internal spaces. IEQ parameters provided by GMS assessment criteria include sustainable products and policies, lighting level, high-frequency ballast, task light and control, IAQ management plan, IAQ, CO₂ monitoring, thermal comfort and control, indoor greenery, post-occupancy survey, and corrective actions and noise level. Ventilation and filtration are assessed at the building level, while indoor greenery and landscape controls are incorporated in the GMS interior scheme [55]. Chiang and Lai [55] proposed a rating scheme comprising nine criteria for the application in the GB scheme of Taiwan, known as ecology, energy saving, waste reduction and health [56]. Based on this system, the building meets the requirements in the whole IEQ if the total of the awarded scores for each criterion is 60 or greater. This system did not incorporate the thermal comfort criterion because the attainment of thermal comfort inside the building in Taiwan requires extensive utilization of air-conditioning (AC) during summer. Additionally, Malaysian GB Index (GBI) rating schemes consider the assessment of IEQ using five parameters, including IAQ, thermal comfort, acoustic or noise, lighting, visual, or view.

Most GB schemes consist of various parameters that can be utilized to evaluate IEQ and ensure that IEQ conditions in the buildings, including hotels, are acceptable with low health issues and high well-being of inhabitants. Therefore, GB schemes are considered useful references and guidance

Table 1: Existing GB schemes for hotel buildings

GB schemes	Building type	Country
Green key global	Motels, hotels, resorts	Canada
National Australian Built Environment Rating System (NABERS)	Hotel	Australia
Earth-check	Hotel	Australia
LEED Building Design and Construction	Hospitality	USA
GBC Energy and Water Benchmarking Tool	Hotel	UAE

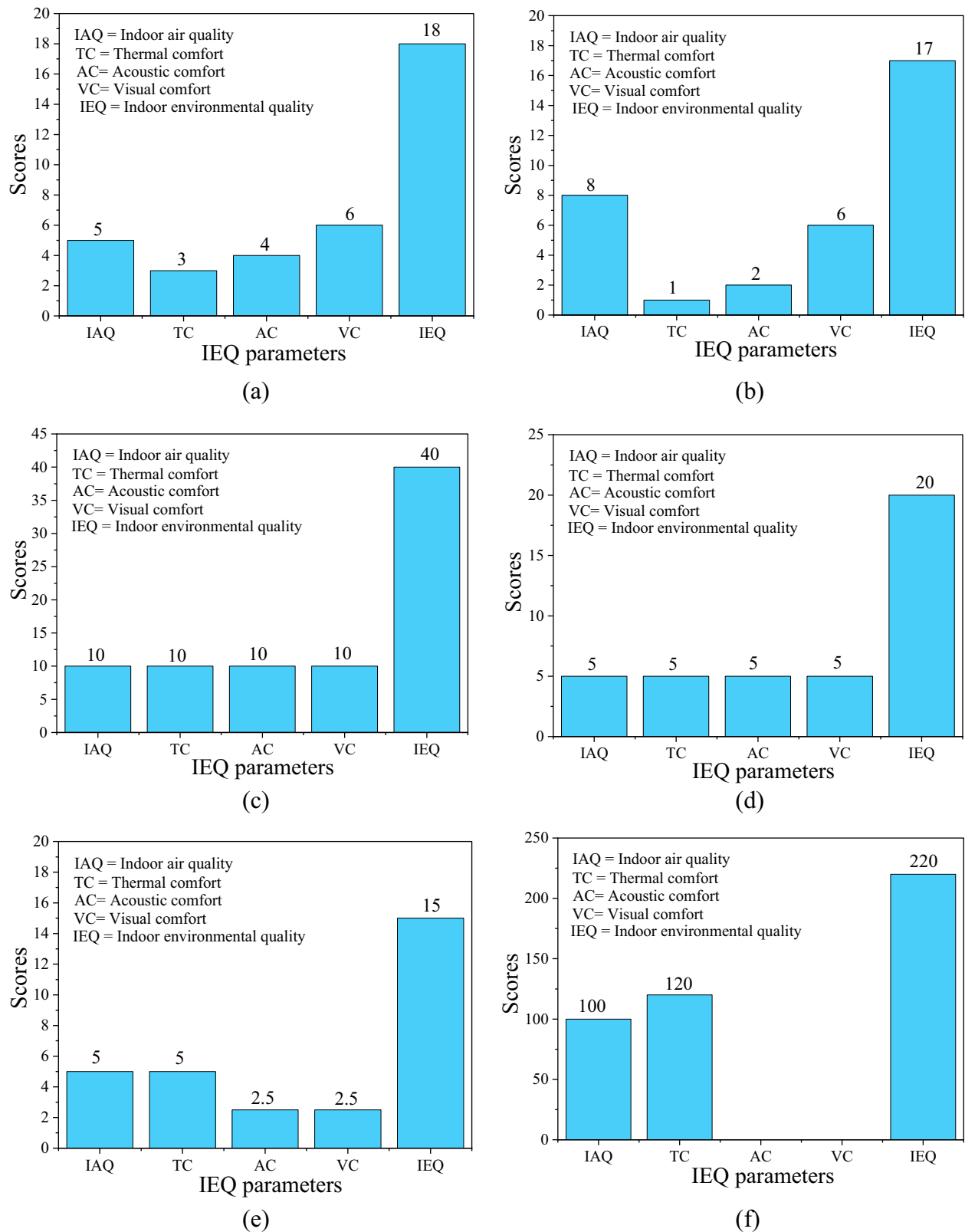


Figure 2: Scores accredited to IEQ in various GB certification schemes. (a) BREEAM (United Kingdom), (b) LEED (United States), (c) DGNB (Germany), (d) ITACA (Italy), (e) LiderA (Portugal), (f) KLIMA (Austria), (g) NABERS (Australia), (h) BCA GMSs (Singapore), (i) EEW (Taiwan), (j) GBI (Malaysia).

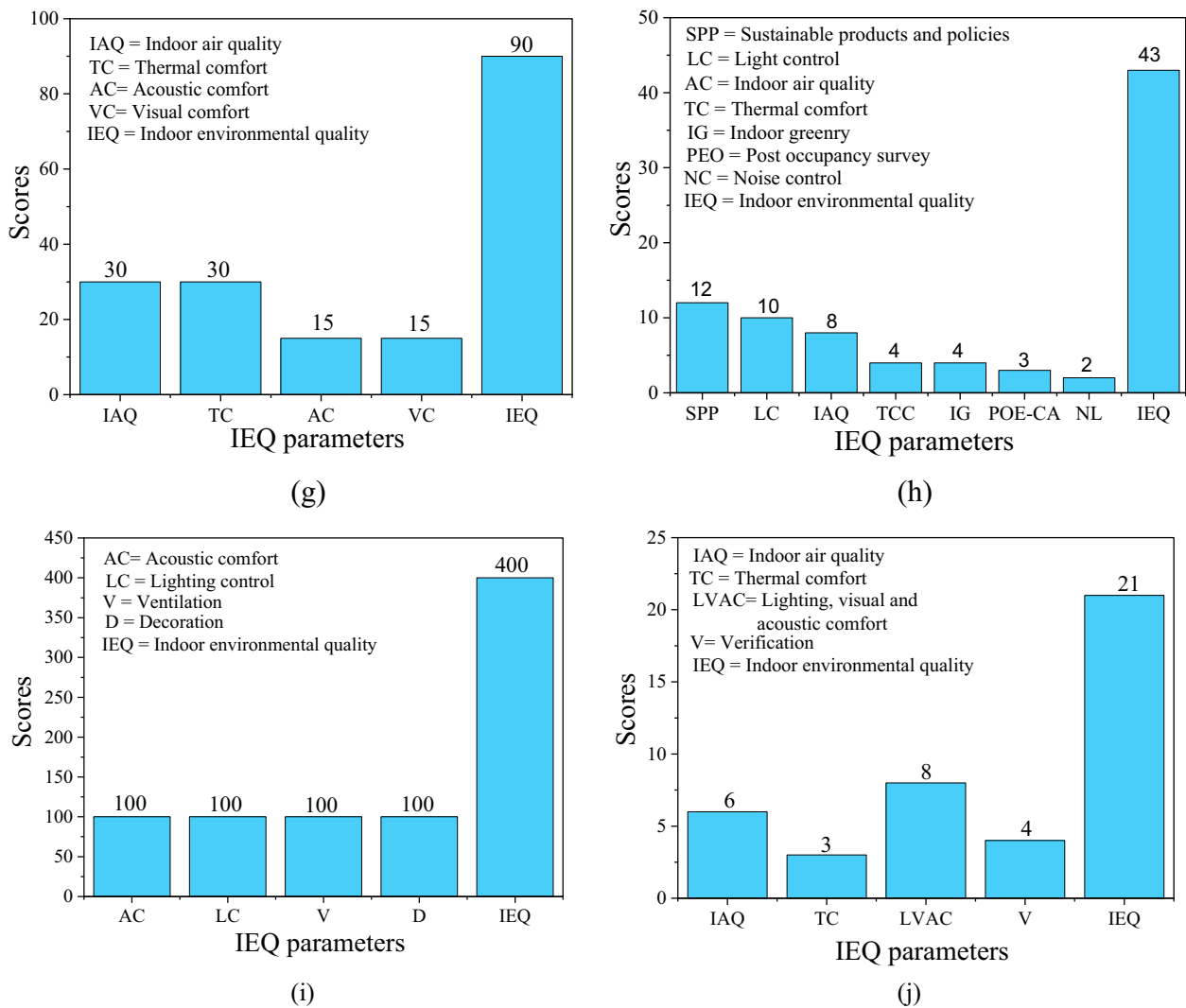


Figure 2: (Continued)

for the selection of IEQ parameters for the assessment of buildings. However, these GB schemes may not be able to include comprehensive IEQ parameters for assessing whether the building or hotels can provide better IEQ to the occupants. Besides, there might even be situations whereby the IEQ performance would be compromised to achieve the other criteria in the existing GB schemes, such as BREEAM, LEED, GMS, and GBI [57].

In addition to the IEQ elements reported in the existing GB schemes, various publications have been presented by various researchers to improve the IEQ in GB (*e.g.*, hotels) [28]. Lee *et al.* [15] carried out a study to assess the IEQ of GB in warm, humid, and tropical climate. It was indicated that ventilation, thermal comfort, and ability to control the indoor environment of the GB were relatively less satisfactory. IAQ, acoustics, and layout did not show a great difference between the buildings. The lighting, outer view, furniture, cleanliness,

and privacy seemed to be significant. Patnaik *et al.* [58] conducted research to evaluate and explain the IEQ parameters and their effect on GBs. 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. Thermal comfort, visual comfort, acoustics, and the levels of volatile organic compounds (VOCs) assist in measuring the IEQ of a building. Suh *et al.* [21] conducted a study to evaluate the IEQ of platinum-certified office buildings located in a tropical climate, considering the effect of various variables, such as thermal comfort, IAQ, lighting, acoustics, cleanliness, and furniture. It was indicated that the IEQ can be measured using decoration and indoor greenery [17,19]. Some of the essential IEQ parameters that might affect the comfort and satisfaction of guests at green hotels are summarized in Table 2.

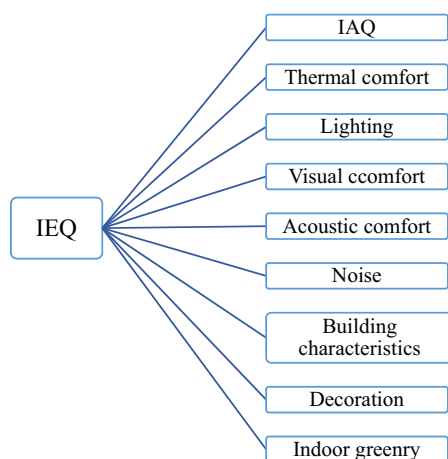
Table 2: Other IEQ parameters from the literature

IEQ parameters	Criteria	Sources
Building characteristics	Location	[58]
	Climate	[58]
	Design and construction	[58]
	Optimal temperature zone	[58]
	Thermal insulation	[58]
Decoration and indoor greenery	Amount of interior decoration	[13,19]
	Usage of environmentally friendly building materials	[13,19]
	Indoor Greenery	[17]

Based on the above, several parameters are important to improve the IEQ at green hotels, as depicted in Figure 3. Therefore, these IEQ parameters seem to have a significant effect on the hotel guests' comfort and satisfaction at green hotels.

5 Relationship between IEQ and guests' comfort and satisfaction

IEQ has a significant influence on the safety and health of human beings. It is essential for hotels to provide a cleaner and healthier environment for their guests and employees. It is essential for hotels to improve the hotel environment to meet the comfort and satisfaction of hotel guests and obtain higher profits. It was observed that good IEQ can decrease the complaints rate of customers by enhancing the work and living environment [59]. However, many hotel guests mentioned some IEQ problems when they

**Figure 3:** Extensive parameters for extensive evaluation of IEQ at green hotels.

make complaints about hotels due to improper thermal, acoustics and lighting actors as well as poor IAQ. Many studies have been conducted to document the influence of several IEQ parameters on hotel guests' comfort and satisfaction, as shown in Table 3.

Accordingly, IEQ, particularly, IAQ, thermal comfort, lighting, and visual and acoustic, are essential factors considered by hotel guests and therefore a factor in determining customer satisfaction. Besides, some literature has also reported that there is an effect of other IEQ parameters including building characteristics, decoration, and indoor greenery, on green hotel guest's comfort and satisfaction. It can be generally found that most studies were performed to evaluate the IEQ parameters within a commercial green hotel. However, the existing studies evaluate the relationship between IEQ parameters and hotel guest comfort and satisfaction in green hotel rooms.

5.1 The relationship between IAQ with green hotel guests' comfort and satisfaction

IAQ is the essential environmental parameter that affects the IEQ and indoor comfort as well as guest satisfaction. It is an indicator to estimate the quality of air in the interior of a building [2]. Besides, it influences the living comfort and mood changes of building occupants. Poor IAQ will not only decrease the occupant's ability to sleep [66], but it also causes irritability and anxiety [67]. Therefore, it is indicated that low quality can result in guest dissatisfaction, which will increase the rate of complaints [19]. Indoor air is defined as the air within the building spaces occupied by the residents, which might be related to the thermal experience [68,69]. There are two types of indoor air contaminants, which include chemical and biological factors. Chemical factors comprise VOCs, NO_x, CO₂, CO, asbestos, radon, ozone, respirable suspended particulates (RSPs), and construction chemicals, while biological contaminants include endotoxins, houseplants, dust mites, pests, pollen, molds, *etc.* [70]. It was indicated that poor IAQ can cause slow mental and high blood pressure in the development of children. Other health issues resulting from poor IAQ include sick-building syndrome (SBS), which refers to symptoms such as nausea, irritated eyes, upper respiratory infections, nose and throat, dizziness, headaches and fatigue, or sleepiness [71]. Studies have indicated that there is a correlation between the indoor environment with asthma and allergies [72].

Several studies have reported the relationship between IAQ issues and the dissatisfaction of hotel guests in many publications. For example, Patnaik and Mishra [73] also

Table 3: Previous studies on the relationship between IEQ and guests' comfort and satisfaction

Ref.	Objective	IEQ parameters	Research methods	Major findings
Gayathri <i>et al.</i> [60]	To determine the key factors influencing the IEQ on green hotel buildings as compared to the conventional hotel	IAQ, thermal, external view, acoustic qualities, lighting and ventilation, cleanliness, furnishings, and maintenance	Interviews and questionnaire survey	It was found that the green hotels can provide better IEQ performance than that provided by the conventional hotel that meets the guest's comfort and satisfaction. However, it was indicated that some parameters, such as acoustics, lighting, and person control degree, were relatively less satisfactory in the green hotels
Qi <i>et al.</i> [25]	To evaluate the perception of guests toward IEQ in green hotels	Space heating, AC, humidity, fresh air, lighting, and noise	Online reviews using a text-mining approach	It was indicated that the AC, humidity and noise were the top factors affecting the IEQ satisfaction of the guest. It was also shown that a higher complaint rate of IEQ can affect the performance of the hotel business. The IEQ complaint showed a positive relationship with energy consumption if the annual energy consumption is higher than 150 kWh/m ² and vice versa
Qi <i>et al.</i> [25]	To evaluate the IEQ and guests' valuations in Italian hotel rooms	IAQ, acoustic, visual, and thermal comfort	Questionnaire survey	It was elucidated that guests' appreciation of comfort is greater than the investment costs required to provide them with comfortable conditions. It was also found that energy efficiency measures are essential to reach the desired indoor comfort level
Wei <i>et al.</i> [53]	To assess the sub-criteria used to evaluate the IEQ in hotel buildings	IAQ, thermal, visual, and acoustic environments	Literature Review	It was indicated that, on average, the contributions of IAQ, acoustic, thermal, and lighting environments to the IEQ rating were 34, 17, 27, and 22%, respectively
Abdulaali <i>et al.</i> [28]	To investigate the IEQ perception of the former green hotels within the GBT certification validity	IAQ, thermal, visual, and lighting comfort	Online reviews using a text-mining approach	It was found that the top IEQ factors affecting the comfort and satisfaction of green hotel guests were thermal and acoustic or noise, with percentages of 36.8 and 45.8%, respectively, while the IAQ, visual or view, and lighting showed only 5.8% for all of them
Kim <i>et al.</i> [3]	To measure the variations in temperature and humidity in hotel guest rooms	Thermal comfort	Field measurement and questionnaire survey	It was found that the potential discomfort in the guest rooms appeared to have a stronger association between outdoor and indoor temperatures, implying thermostat-related discomfort sources
Shen <i>et al.</i> [27]	To evaluate the IEQ complaints in the hotel building	IAQ, thermal, acoustic, and luminous environments	Online reviews using a text-mining approach	It was found that IAQ, thermal, acoustic, and luminous environments can affect the complaints of hotel guests regarding IEQ, indicating their discomfort and less satisfaction
Borowski <i>et al.</i> [4]	To study the IEQ in the guestroom at the hotel located in Poland	IAQ and thermal comfort	Field measurement and analysis	Based on the measurement and analysis, it was found that the humidity and temperature are sustained at a satisfactory level, while it was indicated that the concentration of CO ₂ observed to exceed 2,000 ppm,

(Continued)

Table 3: Continued

Ref.	Objective	IEQ parameters	Research methods	Major findings
Xu <i>et al.</i> [13]	To explore the effect of different decoration styles on the subjective evaluation of the IEQ	Decoration styles, IAQ, thermal, acoustic, lighting environment, and non-lighting factors	Questionnaire survey	which means that it causes discomfort to the guests of the hotel It was indicated that IAQ, thermal, light, acoustic, and non-light visual (decoration) factors have the greatest impact on the subjective evaluation of the hotel IEQ
Suhag and Maan [61]	To investigate the perception and behavioral intention of hotel guest toward green hotels to measure their comfort and satisfaction with green services provided by green hotels	Accommodation and environmental communication	Questionnaire survey and Interviews	It was found that the environmental behavior of guests in the hotel accommodation significantly affects the guest's loyalty toward their perception of environmental communication within the hotel
Zhang <i>et al.</i> [62]	To evaluate the satisfaction of visitors toward IEQ in Australian hotels and apartments	IAQ, thermal environment, acoustics, lighting, availability of space, cleanliness, exterior view, layout/design and maintenance	Web-mining, natural language (NL) processing and analysis	It was indicated that the hotel guests were not satisfied with acoustics, cleanliness, facilities and cleanliness. Overall, it was indicated that the overall IEQ parameters, excluding IAQ showed a small influence on the degree of dissatisfaction across different climate zones
Dang-Van [63]	To examine the relation between the IEQ of green hotels and the intention of customers to revisit as well as to investigate the mediation roles of guest positive affectivity and the considered brand value	IAQ, thermal comfort, acoustics, layout, and lighting	Questionnaire survey	It was found that the IEQ element has a positive effect on the revisit intention of customers. The positive affectivity of customer and perceived brand value showed a positive mediation role between the IEQ and customer revisit intention
Kim <i>et al.</i> [64]	To explore the effect of IEQ on the service quality as well as its effect on customer loyalty and satisfaction	IAQ, thermal environment, acoustics, internal space, and furnishings	Questionnaire survey	It was indicated that there is a significant relationship between the internal spaces and furnishings with service quality and guest satisfaction. It was also shown that the IAQ and thermal comfort significantly influence the guest satisfaction as well as their loyalty
Ma <i>et al.</i> [65]	To explore the relationships between IEQ and occupant dissatisfaction in temporary residences (<i>e.g.</i> , hotels)	IEQ, visual, acoustic, and thermal comfort	Text-mining approach	It was also revealed that windows are perceived as the common source that matters for all four categories of IEQ dissatisfaction. It was also observed that the IEQ value is correlated with increased rental costs when the temporary residences have satisfactory IEQ conditions. It was concluded that IEQ satisfaction can be a key design driver and, therefore, should be considered in building design, management, and real estate finance

highlighted the influence of poor ventilation, humidity temperature, and air movement on surface heat loss in human's body. Asadi *et al.* [74] monitored the IAQ of some star-rated hotels and found that these hotel buildings had problems such as insufficient ventilation speeds, room particle concentrations that were too high, and formaldehyde pollution. Besides, Gayathri *et al.* [60] indicated several effects of IAQ parameters on human health. These effects include SBS, building-related illness, nausea, headache, shortness of breath, drowsiness, fatigue, cancer, lung cancer, heart failure, signs of inflammation, asthma, chest pain, respiratory infections, stroke, and pulmonary and cardiac diseases. Chang *et al.* [75] monitored US hotels and found that when the room was vacant, or the guest was asleep, the particulate matter (PM) level in the room was very low, but when the guest was indoors for activities, PM pollution would increase. Wu *et al.* [76] investigated the access to IAQ based on the grey method. Conventional buildings and green-rating buildings were chosen to evaluate IAQ in terms of smell satisfaction. Gray method-rated 3-star buildings showed satisfactory smell compared to conventional buildings. The 3-star building type was the best among all types of buildings in relation to the fresh air satisfaction. Kim and Oldham [3] assessed the IAQ parameters such as humidity, temperature, CO₂ concentration, and acceptability level of IAQ conditions. It was mentioned that the recorded IAQ parameters varied over time, and there was no repeatability or clear variation patterns. This may be attributed to the preferences and behavior of users. It was also demonstrated that the relationship between IAQ parameters, such as thermal satisfaction and humidity levels, is critical. High humidity also affects the inhabitant's health and enhances the respiratory conditions [77,78].

5.2 The relationship between thermal comfort with green hotel guests' comfort and satisfaction

Thermal comfort is defined as the state or condition of mind that represents satisfaction with its thermal environment and will be significantly affected by air temperature and velocity as well as relative humidity [79]. It plays a key role in IEQ as it influences the comfort level of occupants. It measures the satisfaction of occupants with the thermal surroundings inside the building as well as heating and cooling systems [80,81]. The thermal environment is influenced by many conditions, which can be categorized into personal and environmental factors. Personal factors include physical condition and type of clothing, while environmental factors include air temperature and velocity as well as the moisture of air [20]. Both personal and environmental factors

play a critical role in measuring the thermal comfort in the building [82].

The agent of thermal comfort (*e.g.*, temperature and humidity) are the most common type of physical factors that could significantly influence the inhabitants of the building [83]. It is essential to consider the effective temperature because it represents the perception of an individual on the ambient temperature [70]. Temperature has a high influence on thermal comfort, which in turn affects the health, work performance, and social behavior of building occupants [84]. The humidity is described as the amount of moisture available at a specific place. The amount of moisture is influenced by the temperature. When the temperature is high, the moisture content is also high [85]. Several studies have examined the influence of thermal comfort on the comfort and satisfaction of the occupants. For example, Wargocki *et al.* [86] noticed an improvement in the building occupant's performance when the room temperature is maintained at a comfortable level. Ismail *et al.* [87] found that the temperature level and ventilation were varied based on the preferences of individuals. It was pointed out that the situations responsible for increasing the internal temperature in a building are the external heat transfer from outside the building and the emitted heat from the interior electric devices [88]. Guida *et al.* [47] indicated that thermal comfort is affected by different factors, such as temperature, relative humidity, solar radiation, wind velocity and atmospheric pressure, physical activity (mediator), and thermal clothing (worn garments). Patnaik and Mishra [73] highlighted the importance of thermal comfort in affecting job performance and productivity. It was also indicated that there is a correlation between poor ventilation and heat loss from body surfaces with temperature, humidity, and movement of air. Sahid *et al.* [89] conducted a questionnaire survey approach to evaluate the indoor thermal comfort in the hotel rooms and indicated that solar radiation had a significant effect on changing the temperature in the hotel room and consequently the thermal comfort. Vella *et al.* [90] also found that there is a lack of overall thermal mass of the building and higher solar gains through glazing elements, giving a minimal inertia against the fluctuations of exterior temperature. Kim and Oldham [3] characterized the variations in the profiles of internal temperature and humidity in guest rooms. It was found that the potential discomfort occurred in the rooms with a stronger association between outdoor and indoor temperatures. Al-Sakkaf *et al.* [88] highlighted some passive architectural design interventions to enhance thermal comfort as well as required building cooling energy. It was shown that using double low-E glass and a double wall with polystyrene thermal insulation can improve the

thermal comfort inside the building and decrease the energy performance and the emissions of CO₂ to 17 and 9%, respectively.

5.3 The relationship between lighting with green hotel guests' comfort and satisfaction

Lighting is an essential characteristic of IEQ because it influences human health and well-being. It affects the physical and psychological state of occupants. It also influences the health, comfort, and productivity of building inhabitants because it causes high levels of fatigue [91]. Various human activities in indoor spaces are vulnerable to the effects of different lighting sources (*i.e.*, LEDs). Therefore, it is important to create a healthy and comfortable lighting environment inside the hotels [92] by using modern light control technology, which provides physical and psychological comfort to occupants [93]. Utilizing modern lighting control technology to sufficiently provide humans with psychological and physiological comfort is an important means to improve their work efficiency and well-being [93]. Building designers should consider proper dimensions to attain optimal lighting comfort. These dimensions include light levels, light transmission, glare control, and consistency [91]. GBs also utilize natural sunlight to decrease the consumption of energy and provide the occupants with better visual comfort. Appropriate illumination obtained from natural and artificial light contributes to enhancing the health, well-being, and satisfaction of the occupants, indirectly improving their performance as well as productivity.

Previous research indicated that insufficient lighting could lead to numerous health issues, including eye irritation, dry eyes, headaches, and allergic reactions [94]. It was also reported that the absence of daylight can affect the ability of building inhabitants to improve their performance, as daylight is associated with the minimization of health issues [94]. Musa *et al.* [95] stated that high-quality lighting can enhance the vision, emotion, focus, and attitude of the person. Boyce [94] also claimed that natural lighting can decrease seasonal anxiety, while excess lighting can cause unwanted glare. Besides, a sufficient amount of lighting can influence morale, quality, energy efficiency, and productivity [84]. Aries *et al.* [96] evaluated the recent research on the effect of daylight exposure on human health. It was indicated that there is proof of the link between daylight and its potential effects on health. Salvadori *et al.* [97] pointed out that it is important to adopt a standardized procedure of evaluation that would permit the

lighting designers to confront the possible interventions and adopt the most adequate to establish the conservation and comfort problems of the lighting environment.

5.4 The relationship between visual with green hotel guests' comfort and satisfaction

The visual environment provides contact people with the external world because it translates color, light, and shapes to the human brain. Visual comfort is described by the glare and contrast concepts, which are influenced by the viewer's field of vision [98]. It greatly influences productivity [99,100] and is critical for the comfort, satisfaction, and well-being of occupants [91,101]. It was reported that visual comfort is related to the illuminance and general appearance of the interior environment, where the amount of illumination in the living place is essential and is regarded as an important guideline [102]. It was also pointed out that a good luminous environment is one of the critical parameters for attaining the comfort and satisfaction of hotel guests [19]. This can be achieved by using an effective combination of natural and artificial lighting sources that create high-performance lamination space for enhancing the quality of lighting within the building [13,103]. The glare obtained from the sunlight and sky can also induce significant issues for the building occupants. Some studies attempted to report the correlation between the lighting and guest comfort and satisfaction. For example, Musa *et al.* [95] mentioned that good lighting quality could enhance the visual comfort of people and improve their attention, attitude, and emotion, while high direct artificial and natural sunlighting can produce a glare that causes visual discomfort. Previous studies also indicated that visual comfort affects the health of occupants and causes headaches, dry eye, and early eye fatigue, as well as reduced concentration and visual function [27]. Besides, it was reported that the wall color (*i.e.*, rose, blue, yellow, and green) in the guestroom can improve the focus, mood, and productivity of building occupants [84,104]. Alapieti *et al.* [105] pointed out that the wooden exterior materials can induce positive or neutral impacts on the IEQ (*i.e.*, humidity fluctuations of interior air).

5.5 The relationship between acoustic/noise with green hotel guests' comfort and satisfaction

Acoustic comfort is described as conductivity to sound intelligibility, sound privacy, and concentration with fewer

annoyances and distractions. A good acoustic can reduce the external noise from disrupting the indoor environments. Sound pollution can cause harmful hearing implications. Exposure to a high load of noise can result in hearing issues and permanent damage to the ears. Sound can affect the personal motivation and performance as well as the productivity and effectiveness of building occupants [58,106]. It was reported that del Puerto [107] mentioned that maximum background noise is approximately 35 dBs in an empty space, while the reverberation ranged from 0.6 to 0.7 s. Excessive noise in spaces can negatively influence the psychosocial relationships with work performance and cause many health problems, such as hearing loss and increased blood pressure [84,108]. Chronic exposure to noise can also impair reading skills and hinder cognitive functioning [109]. High noise levels can disturb the building occupants and also affect their ability to hear in the long term [110].

In hotel facilities, it is common that noise includes indoor and outdoor noises, which are generated by natural or human sources. The natural sources of noise include waves or wind noise, while human noise is caused by transportation, household appliances, or industrial facilities [111]. Poor acoustic environment can be caused by traffic or neighbors' noises [112]. This noise is generally related to the architectural design of hotel buildings. Jablonska and Trocka-Leszczynska [113] indicated the acoustic comfort of a hotel can be improved by providing a good structural design of a building with a better acoustic effect. It was also mentioned that the level of noise is usually attributed to the room surface absorption characteristics and the volume of internal space [114]. The consideration of building acoustic quality is an effective method to enhance the comfort of the building, and the hotel buildings should be concerned with the complaints of guests and improve the acoustics to meet the satisfaction of customers. For instance, absorbing materials of sound should be provided in rooms to attain better noise control to eliminate the discomfort of customers. Recent similar studies by Haghighi and Jusan [115] further reinforce the earlier concept that poor acoustic environments in spaces affect the performance of the occupants by negatively impacting communication and interaction.

5.6 Relationship between the building characteristics and green guests' comfort and satisfaction

Building structures are constructed to provide shelter for the occupants from the external harsh environment with

the provision of high-quality interior conditions. The building protects its inhabitants from harsh environmental conditions, such as storms, earthquakes, and precipitation, as well as maintains a comfortable internal environment [116]. The indoor environment must be more comfortable than the external one. The building skeleton, such as the foundation, exterior wall, doors, windows, and roof systems, are the mediums between the indoor and outdoor environments. Its components function as barriers playing an essential role in providing the required energy to maintain a comfortable indoor comfort [117]. In addition to the aesthetic quality, a GB should have the energy properties of the wall and how the design and materials influence the indoor spaces [117]. According to Patnaik *et al.* [58], building characteristics, such as location, climate, design, and construction, make a significant contribution to the IEQ. MH and AH [117] assessed the effectiveness of the facade utilized in green office buildings as the interface of the ambient climate to the IEQ. It was shown that most of the IEQ parameters meet the criteria established by GBI non-residential new construction tools despite the fact that the envelop of the building comprises different types of facades.

5.7 Relationship between the decoration and green guests' comfort and satisfaction

Due to the enormous demand for hotel aesthetics in the tourism market, hotel rooms with different decoration styles have been designed and constructed. Various decoration styles with different furniture layouts and decoration materials have been used. Therefore, the motivation on whether various decoration styles influence the subjective evaluation of the hotel [19]. To create a memorable experience in the hotel, the interpersonal relationship between the hotel environment and guests plays an essential role, as same as tangible elements, such as the guest rooms' impressive decoration [118]. Numerous studies have been conducted researches on indoor landscapes, such as the hotel IEQ transformation using various decoration environments, decoration materials, and plant configurations [13,119]. The guest's emotions are sometimes affected by tangible factors, such as layout, exterior, and interior decoration, where hospitality is emphasized on the emotional dimensions affecting the interpersonal relationship between the host and guest [95]. According to Lam *et al.* [120], the aesthetics of buildings include architectural and interior design as well as decoration that contribute to the attractiveness of GB. It was found that the functional benefits, such as decoration of the hotel may lead to the satisfaction of customers. The IEQ

may be intensified by other aspects of interior design, such as plants/flowers, pictures/paintings, wall decorations, and furniture, which may affect the behavior of customers.

5.8 Relationship between the indoor greenery and guests' comfort and satisfaction

The indoor green places within a building, such as indoor green walls, indoor green spaces, plants, green decorations, and natural lights through glass windows, are essential nature-based solutions (NBS) to attain sustainable and resilient buildings [121]. In the hotel building context, a green indoor physical environment is also an important component of NBS. Besides, the concept of the hotel's green physical environment includes all aspects of interactions that take place between the hotel guests and the indoor environment inside the hotel because it can be a factor in hotel service quality and performance as well as a criterion for quality assessment [122]. Previous studies indicated that indoor greenery can influence the satisfaction of occupants. Gray and Birrell [123] pointed out that bringing greenery or a natural environment inside an office building can positively affect satisfaction. Greenery in offices was found to be related to productivity and the reduction of stress. Moya *et al.* [124] reported that indoor greenery can act as a passive acoustic insulation system to decrease sound levels. Han *et al.* [125] stated that the indoor green spaces within a hotel significantly improve the perceptions of well-being and self-rated mental health of guests. Xiao *et al.* [126] pointed out that indoor vertical greenery can enhance visual satisfaction.

6 Conceptual model between IEQ parameters and hotel guest's satisfaction

This study investigates the relationship between the IEQ parameters with guests' comfort and satisfaction through a comprehensive literature review. It proposes a conception model on the relationship between IEQ parameters, such as IAQ, thermal comfort, lighting, visual comfort, acoustic comfort/noise, building characteristics, indoor decoration, and indoor greenery, with guests' comfort and satisfaction in green hotels, as shown in Figure 4. The proposed model can be implemented for the comprehensive evaluation of IEQ in green hotels. Therefore, it reflects the recent advancement in the field of green-certified hotel in green hotels.

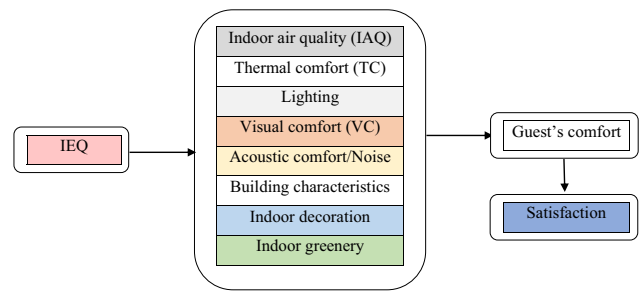


Figure 4: Conceptual model on the relationship between IEQ parameters and guests' satisfaction.

7 Future perspectives and relevant solutions

Although IEQ and building occupants have been on the agenda of the hotel industry, a new perspective is placed on the features of hotel buildings that promote the comfort and satisfaction of green hotel guests. When constructing or renovating cost-effective and eco-friendly hotel buildings, it is necessary to consider the IEQ to meet the health, comfort, and satisfaction of hotel guests. Better IEQ can result in improving the health and well-being of guests and increase their intention to revisit the green hotel. A holistic approach to evaluating the IEQ, supported by cutting-edge technologies and enabled by individualized services, is required in the future to address the critical issues affecting the IEQ and provide sustainable solutions to improve the hotel building viability and support the health, comfort, and satisfaction of green hotel guests. Relevant solutions for the IEQ challenges have to be established from the initial evaluation of the hotel building to the implementation and management services for maintaining a healthier and viable indoor environment. Besides, a metric of IEQ is useful for the appropriate characterization of IEQ in hotel buildings, and it is considered priority because it would allow the full assessment of IEQ performance and lead to technological development.

8 Conclusion

To provide an understanding of the relationship between IEQ performance and hotel guests' comfort and satisfaction at green hotel buildings, this research aims to explore the effects of several IEQ parameters on guest's comfort and satisfaction based on a systematic review approach. Based on the findings of the systematic review, it was found that there is a positive relationship between IEQ parameters, such as IAQ, thermal comfort, lighting, visual/view, acoustic

comfort, building characteristics, decoration, and indoor greenery with hotel guest's comfort and satisfaction. A simple conceptual model was then suggested to correlate the IEQ parameters with the comfort and satisfaction of hotel guests and create a reference for future development of extensive IEQ rating schemes. Overall, the findings of this review can provide the hotel management with a rationale for adopting various IEQ parameters to meet overall guest satisfaction. However, this study presents the indoor factors affecting the IEQ, and the indoor environment is possibly influenced by other outdoor conditions, the factors impacting thermal comfort, which are crucial in improving the comfort and satisfaction of hotel guests.

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