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Impact of indoor environmental quality satisfaction on guests' rating of Australian tourist accommodation

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Abstract: Numerous studies have shown that indoor environmental quality (IEQ) plays a significant role in occupant satisfaction in office buildings, yet insufficient research has been done on how IEQ factors affect customer ratings of hotels and serviced apartments. This study analyzed 543,213 guest reviews from 1,397 Australian hotels and serviced apartments with 2-5 stars on Booking.com using web-mining, natural language processing, and the Three-Factor Theory of customer satisfaction. The sentiment polarities for nine IEQ factors were calculated to estimate the IEQ satisfaction. The Three-Factor Theory and mixed effects models were applied to model the asymmetric effects of IEQ factors on guests rating scores. All IEQ factors except for exterior view were considered Basic Factors of customer satisfaction, meaning that customers expect satisfactory performance of these factors. Exterior view served as an Excitement Factor in accommodations with 3 stars and lower, a Performance Factor in those with 4 stars, and a Basic Factor in 5-star guest homes. When IEQ performance was deemed satisfactory, the most influential factors in determining overall satisfaction were exterior view, cleanliness and maintenance, and acoustics. When IEQ performance was unsatisfactory, the most influential IEQ factors were cleanliness and maintenance, indoor air quality, and acoustics.

Keywords: Indoor environmental quality; Three-Factor Theory; natural language processing; sentiment analysis

1. Introduction

The Australian tourism industry contributes significantly to the nation's economy. During the 2018–2019 financial year, the industry generated 61.9 billion in revenue, representing 3.1% of Australia s gross domestic product (Australian Bureau of Statistics, 2022). Customer satisfaction towards tourist accommodations plays a critical role in the success of the hospitality industry. On the one hand, satisfied customers are more likely to recommend the hotel to their friends and family, leading to increased bookings and revenue. On the other hand, disgruntled travellers are more likely to leave unfavourable online reviews of the hotel, which not only undermines the hotel s brand and image, but also reduces hotel revenue by scaring off new customers (Li et al., 2020). In a competitive market, maintaining high

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levels of customer satisfaction in hospitality buildings is crucial for the continued growth and success of the hospitality industry in Australia. Therefore, the industries must have a thorough understanding of the factors that influence the guests' satisfaction and rating of the guest homes.

1.1. Indoor environmental quality and overall satisfaction

Indoor environmental quality (IEQ) refers to the physical and psychological conditions within a building that can affect the health, well-being, and productivity of the occupants (U.S. Green Building Council, 2014). Factors that contribute to IEQ include temperature, humidity, lighting, air quality, acoustics, to name a few. Employing a post-occupancy evaluation approach, numerous IEQ studies investigated on the association between IEQ factors and the overall satisfaction of office employees. These studies have revealed that IEQ plays a significant role in determining the overall satisfaction with the workspace (e.g., Kim and de Dear, 2012; Cheung et al., 2021).

Recent review studies (Zhao and Li, 2023; Roumi et al., 2022) indicate, however, that the combined effects of IEQ satisfaction on overall satisfaction are complex and nonlinear, as different IEQ factors may exert varying degrees of influence on satisfaction. Tang et al. (2020) discovered that the impact of a specific IEQ factor on occupants' overall IEQ satisfaction varied based on its relative level in comparison to other factors; the IEQ factor with the lowest level of satisfaction will have the greatest impact on the occupants' overall IEQ satisfaction regardless of the perfection of the other IEQ factors. Cao et al. (2012) also found that unsatisfactory thermal and acoustic conditions can override satisfaction with other IEQ factors, resulting in a substantial decrease in overall satisfaction. However, this non-linear relationship between individual IEQ satisfaction and the overall satisfaction has been neglected in many previous studies where a linear relationship was assumed.

1.2. The Three-Factor Theory

The Three-Factor Theory originated from the Kano Model (Kano *et al.*, 1984). In 1984, Professor Kano and his colleagues proposed the Kano model of attractive quality, which postulated that the individual quality attributes of a product have an asymmetric effect on overall customer satisfaction, and that different attributes have varying effects. In 2008, Füller and Matzler (2008) proposed the "Three-Factor Theory of Customer Satisfaction" as a modification of Kano's theory, suggesting that customers have different levels of satisfaction with products or services based on three factors: Basic Factors, Performance Factors, and Excitement Factors.

- Basic Factors: also known as dissatisfiers, refer to the minimum requirements that customers expect from a product or service. The absence of these factors may elicit dissatisfaction; however, their presence does not guarantee satisfaction.
- Performance Factors: satisfaction is proportionally influenced by performance factors whereby high performance elicits satisfaction and low performance results in dissatisfaction. The effects of these attributes on overall satisfaction are linear and symmetrical.
- Excitement Factors: also known as satisfiers, are the extra features or characteristics that customers don't expect, but when present, result in a significant increase in satisfaction. However, their absence does not necessarily result in dissatisfaction.

1.3 Bridging IEQ satisfaction and guest ratings in hospitality buildings

Kim and de Dear (2012) introduced the Three-Factor Theory (Kano model) to the built environment studies for the first time, where they examined the impact of individual IEQ factors on overall workplace satisfaction. It was found that Basic Factors included temperature, noise level, amount of space, visual privacy, adjustability of furniture, colours and textures, and workspace cleanliness, with the negative impacts of these factors outweighing their positive counterparts in determining the overall satisfaction; Proportional (Performance) Factors included air quality, amount of light, visual comfort, sound privacy, ease of interaction, comfort of furnishing, building cleanliness and maintenance. These factors are proportional to the overall satisfaction. There were no Bonus (Excitement) Factors detected. However, the paucity of research on IEQ in hospitality establishments leaves us uncertain about the potential asymmetric impact of IEQ on customer satisfaction in hotels and serviced apartments, and the nature of this asymmetry.

In hospitality industries, there are numerous research studies that have applied the Three-Factor Theory to understand the asymmetric relationship between the product/service attributes and overall customer satisfaction. According to the findings of Albayrak and Caber (2015), the Basic Factors that contribute to customer satisfaction of a hotel included animation, child amenities, cleanliness, food and beverage, personnel, pool, and room decoration. Performance Factors were determined by beach access and the technical capabilities of hotel rooms. In a similar vein, Matzler et al. (2006) found that Basic Factors, such as reception, friendliness, service, and hotel room, played a crucial role in customer satisfaction. Additionally, the presence of a wellness area was identified as a Performance Factor, while the hotel restaurant and breakfast offerings were considered Excitement Factors. However, due to their discipline-specific focus, these studies did not examine the impact of IEQ factors on guests' overall ratings.

1.4 Aims of the study

This study constitutes an early endeavour to investigate the suitability of the Three-Factor Theory in elucidating the IEQ impacts on overall satisfaction in hospitality buildings, employing online reviews as a data source. This project aims to gather guest reviews from Booking.com on hotels and serviced apartments in Australia and examine the association between guests' satisfaction with various IEQ factors and their ratings of the tourist lodges. By applying web-mining, natural language processing (NLP), and the Three-Factor Theory, we aim to answer the following questions:

- Do IEQ factors in Australian hotels and serviced apartments have asymmetric effects on guests' ratings?
- Which IEQ factors are Basic Factors, Performance Factors and Excitement Factors, respectively?
- How much variance can IEQ satisfaction account for in the guests' ratings?

2. Methods

2.1 Dataset

A crawler was created to scrape guest reviews from the Booking.com website spanning from May 2019 to May 2022. The crawler had filters for city, property type, and star rating. The cities included Sydney, Melbourne, Brisbane, Gold Coast, Sunshine Coast, Perth, Adelaide, Hobart, Darwin, and Canberra. The property types were limited to hotels and apartments. The star ratings ranged from 2 stars to 5 stars and excluded the "unrated" category. A total of 1,470,709 reviews were collected and written into a CSV file and included details such as accommodation name, suburb, city, star rating, overall guest rating,

nationality of the guest, room type, duration of stay, check-in month, check-in year, individual guest rating, positive comments, and negative comments. Reviews written in languages other than English were translated into the English language. Data pre-processing removed positive and negative reviews that were both fewer than five words. The resultant dataset consisted of 759,877 reviews from 1,402 Australian hotels and serviced apartments.

2.2 IEQ classification

The dataset was expanded from the reviewer level to sentences level, allowing multiple rows per review. A semi-supervised word-embedding model categorized guest review comments into nine IEQ factors—thermal environment, indoor air quality (IAQ), lighting, acoustics, available space, facilities, exterior view, cleanliness and maintenance, and layout & design. The nine IEQ factors were derived from the Building Occupancy Survey System Australia (BOSSA) (Candido et al., 2016), an Australian post-occupancy evaluation tool designed for office buildings but modified to meet the unique requirements and characteristics of tourist accommodations. This study excluded IEQ factors that were mentioned infrequently in online reviews or that could not be reliably identified by words or phrases, e.g., individual control, colour and textures.

For each IEQ factor, we manually selected seed words frequently mentioned in the reviews, shown in Table 1, and fed them into a bespoke semi-supervised NLP model (Zhang et al., 2023) to detect IEQ-related sentences. We discarded sentences that were not associated with any IEQ aspect. Despite this, the sentences mapped to IEQ aspects contained numerous non-IEQ comments because IEQ vocabulary was used in a variety of polysemous contexts. For instance, “large” can refer to the size of the room or other objects; however, only the former is relevant to IEQ. After mapping review sentences to IEQ factors, sentences with non-IEQ contexts were filtered out with the help of a manually curated lexicon of phrases irrelevant to IEQ contexts. These irrelevant phrases were modified based on previous studies (e.g., Qi et al., 2017) with a similar focus.

Table 1: Seed words for nine IEQ factors (Source: Zhang et al., 2023).

IEQ factors	Seed Words
Thermal Environment	warm, cold, freezing, chilly, hot, heat, scorching, sweltering, melt, sweat, humid, muggy, clammy, steamy, draughty, drafty, temperature, cool, snow, snowy
Indoor Air Quality	air, air circulation, ventilation, aerate, breeze, smell, smoke, stuffy, stink, stunk, stench, reek, airless, stale, odour, airtight, musty, mould, air purifier, air flow, airy
Lighting	bright, dark, glare, dazzle, dim, dusky, light, glow, lamp, block out, shady, lighting
Acoustics	noise, loud, quiet, sound, sound insulation, soundproof, disturbance, silent, hear, overhear, rowdy, roaring, rattling, blaring, racket, earphone, earplug
Available Space	spacious, space, large, huge, small, enough room, tiny, cramped, compact, congested, poky, size, roomy
Facilities	facilities, gym, equip, sauna, microwave, amenities, broken, damaged, cracked, not work, holes, chipped, air conditioner, air conditioning, aircon, AC, lifts, elevator, bed, furniture, fridge, tv, toilet, balcony, kitchen, laundry, towels, hot water, shower head, fly screens, faulty, pool, Wi-Fi, internet
Exterior View	view, overlooking, facing, outlook, scenery
Cleanliness & Maintenance	clean, cleanliness, (un)hygienic, (un)tidy, spotless, dirt, disgusting, dusty, filthy, dingy, grubby, stain, wash, scrub, leaking, cockroach, bugs, insects, cobwebs, rubbish bin, housekeeping, maintenance, maintained, renovated, renovation, refurbished, updating, modern, décor, decoration, decent, dated, old, run down, dilapidated, rusty, art deco, scum
Layout & Design	layout, design

To validate the IEQ classification method, a comprehensive and systematic test set has been curated. Most review sentences addressed one to three IEQ factors. During the curation process of the validation dataset, we ensured that the proportions between sentences mentioning only one IEQ factor and sentences mentioning two or three IEQ factors were maintained similar to that of the entire dataset. The sentences in the validation test set were manually categorised into various IEQ factors. These manually generated categorisations were then compared with the categorisations generated by the AI Classifier to evaluate the accuracy of the AI-generated categorisations. The validation process is described in detail in Zhang et al. (2023).

2.3 Sentiment analysis

This study employed aspect-based sentiment analysis to evaluate the sentiment polarities of nine pre-determined aspects wherein each aspect referred to a distinct IEQ category. A bidirectional Long Short Term Memory (BI-LSTM) deep neural network model (Graves & Schmidhuber, 2005; Yadavilli & Seshadri, 2022) was utilized for this purpose. A BI-LSTM-based deep neural network classifier was trained to classify each review-IEQ factors combination into a 3-point sentiment polarity scale of "satisfied", "neutral", and "dissatisfied". A "neutral" category was assigned in cases where the sentence did not make any explicit reference to the IEQ factor in question. The classification accuracy for all IEQ factors ranged between 92% and 96%. The details about the architecture, training algorithm adopted, optimization objective and hyper-parametric settings used by the BI-LSTM model can be found in Zhang et al. (2023).

2.4 Data analysis: regression models with dummy variables

Prior research has extensively employed regression analysis with dummy variables to investigate asymmetric relationships across diverse contexts (Li et al., 2020; Kim and de Dear, 2012; Füller and Matzler, 2008). The basic logic is to divide the performance of a product or service attribute into three groups, high, medium, and low (Figure 1), and then compare the **absolute** differences in overall satisfaction between these groups. If the difference in satisfaction between the mid-performance and low-performance group is greater than that between the mid-performance and high-performance group, the attribute is identified as a Basic Factor (the bottom curve in Figure 1), as low performance has a greater impact on dissatisfaction. If the difference in satisfaction between the mid-performance and high-performance groups is greater than that between the mid-performance and low-performance groups, the attribute is identified as an Excitement Factor (the top curve in Figure 1), as high performance leads to high satisfaction. If the difference in satisfaction between the mid-performance and high-performance groups is roughly equivalent to the difference between the mid-performance and low-performance groups, the attribute is identified as a Performance Factor (the middle line in Figure 1), as performance changes proportionally to satisfaction.

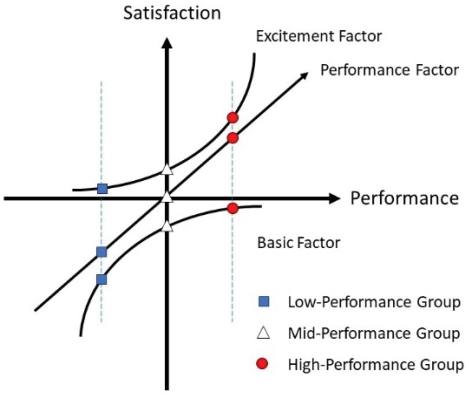

Figure 1 The Three-Factor Theory (adapted from Matzler et al., 2004)

To examine the IEQ impacts on guest ratings, this study categorised IEQ performance levels into three groups based on the sentiment polarity values of each IEQ factor. To be specific, a "satisfied" sentiment polarity was deemed as high IEQ performance, a "neutral" polarity deemed as medium performance, and a "dissatisfied" polarity deemed as low performance. Dummy coding is a way of representing groups of people using only zeros and ones. In accordance with existing literature, two dummy variables were created, and a 0 and 1 binary coding scheme was applied. We chose the medium IEQ performance group as the reference group because we were interested in determining whether the high IEQ performance group led to greater overall satisfaction than the mid-performance group, and whether the low IEQ performance group had lower satisfaction than the mid-performance group. The reference group had a dummy coding of (0, 0). A dummy variable (coded 1, 0) was assigned to the high-performance group, while another dummy variable (coded 0, 1) was assigned to the low-performance group. This procedure was repeated for nine IEQ factors.

This study tested both simple linear regression models with dummy variables and mixed effects regression models with dummy variables and compared their goodness-of-fit parameters. According to Field (2013), the responses obtained from a subject in a multilevel model can be understood as the combined influence of fixed and random effects. Fixed effects contribute to the overall population mean,

while random effects alter the covariance structure of the data. The comparison of two models showed that the mixed effects model, which took into consideration the hierarchical structure of the data (Snijders & Bosker, 2012), produced a superior goodness-of-fit value compared to the simple regression model. Hence, a mixed effects model was chosen for the data analysis, and the results are presented in the following sections.

A mixed effects model was constructed using the dummy coding, wherein the dependent variable was the guest rating of the premise (also referred to as the overall satisfaction), and the independent variables consisted of nine IEQ items with dummy variables. According to the findings of Li et al. (2020), IEQ impacts on overall satisfaction was mediated by factors such as the star ratings of the premises, locations, travellers' origin (whether they were national or international travellers), and the year of travel. In our prior study utilising the identical dataset, it was discovered that guest ratings exhibited a statistically significant decline after the onset of the COVID pandemic (Apr 2020 in Australia) in comparison to pre-pandemic levels (Zhang et al., 2023). Hence, to accurately model the asymmetric effects of IEQ factors, the mixed effects model accounted for the differences between cities, nationality, and time of travel in relation to COVID-19 by adding three covariates in the model.

Table 2 presents the statistical summary of the hotels and apartments examined in the current study. The database comprised of IEQ-related reviews from a total of 543,213 visitors from 188 different nations. These visitors had stayed in a collective sum of 1,397 hotels and serviced apartments located in ten cities across Australia. The database consisted primarily of Australian visitors, comprising 90.4% of the reviewers, with international visitors representing only 9.6%. These visitors have evaluated their lodging experience on a numerical scale ranging from 1 to 10 through the platform provided by Bookings.com. The data presented in Table 2 implies a positive correlation between the star ratings of tourist lodgings and the average guest ratings. Given that the guest accommodations categorised as "2 star" and "3 star" facilities accounted for only 1.5% and 13.7% of the total entries in the database, respectively, these two categories were combined for the purpose of conducting statistical analysis. To develop mixed effects models, the dataset was partitioned into three subsets based on the three categories of star ratings, specifically, 3 stars and below, 4 stars, and 5 stars.

Table 2. Breakdown of hotels and apartments according to accommodation star ratings

Star Rating	No. of Hotels/ Apartments	Percentage (%)	Number of Reviews	Average Guest Rating
2 Star	21	1.5	3,660	6.9
3 Star	191	13.7	39,944	7.3
4 Star	829	59.3	308,181	7.9
5 Star	356	25.5	191,428	8.2
Total/Group Mean	1,397	100	543,213	7.9

Both a two-level and a three-level hierarchical structure (customer-hotel, and customer-hotel-city) were tested while developing mixed effects models. In this study, a two-level structure was used since the goodness-of-fit measures and covariance parameters showed that a three-level structure did not enhance the model's fit over a two-level structure. When developing mixed effects models for three

categories of star ratings, random slopes for all independent variables were evaluated; if they did not enhance the models' goodness-of-fit, they were removed from the model. Equation (1) represents the mixed effects model being tested. In the subsequent analysis, we only report and interpret the fixed effect coefficients. Equation (1) yields two fixed-effect coefficients for each of the nine IEQ items: one coefficient b_x pertained to the high-performance group, examining the effect when the sentiment polarity of the IEQ item was satisfied, while the other coefficient $b_{x'}$ pertained to the low performance group, assessing the impact when the sentiment polarity of the IEQ item was dissatisfied.

$$Y_{ij} = \left(b_0 + u_{0j}\right) + \left(b_1 + u_{1j}\right)HP_{thermalcomfort,ij} + \left(b_{1'} + u_{1'j}\right)LP_{thermalcomfort,ij} + \cdots + \left(b_9 + u_{9j}\right)HP_{layout,ij} + \left(b_{9'} + u_{9'j}\right)LP_{layout,ij} + \left(b_{city} + u_{city,j}\right)city_{ij} + \left(b_{nationality} + u_{nationality,j}\right)nationality_{ij} + \left(b_{time} + u_{time,j}\right) time\ of\ travel_{ij} + \cdots + \epsilon_{ij} \quad (1)$$

In Equation (1), Y_{ij} is the customer *i*'s rating of the lodging *j*; $(b_0 + u_{oj})$ denotes a random intercept where b_0 is the intercept of the overall model and u_{oj} is the variability of intercepts around the overall model; *HP* denotes the dummy set for high IEQ performance groups; *LP* denotes the dummy set for low IEQ performance groups; $(b_x + u_{xj})$ refers to a random slope for the HP dummy sets, where b_x is the slope of the overall model and u_{xj} is the variability of slopes; $(b_{x'} + u_{x'j})$ refers to a random slope for the LP dummy sets. *city* is a categorical variable for the ten Australian cities; *nationality* and *time of travel* are two binary variables indicating if the traveller was from Australia or overseas, and if the travel was before or after the pandemic (Apr 2020 in Australia), respectively; $\mathcal{E}_{ij}$ is the error for the *i*th customer from the *j*th lodging. In the reference group, both dummy variables HP and LP were coded as 0, thus the model estimated the average guest ratings when IEQ performance was deemed as neutral across all nine IEQ factors. This estimation was conducted for a reference city, nationality, and time of travel. In the HP group, the dummy variable HP was coded as 1, and LP was coded as 0, and the regression coefficients b_x indicated the difference between the average ratings of the HP and the reference group for nine IEQ factors, respectively. Similarly, In the LP group, the dummy variable LP was coded as 1 and the HP as 0, then $b_{x'}$ indicated the differences between the average ratings of the LP and the reference group.

The coefficient of determination, denoted as R^2, provides a measure of the goodness-of-fit of a model, which cannot be derived from the Akaike Information Criterion (AIC) commonly employed in mixed-effects models. The incorporation of the statistical metric "variance explained" (R^2) as a relevant summary indicator in mixed-effects models has not been frequently observed in prior studies. In this project, the pseudo-R^2 measures were computed using the methodology proposed by Nakagawa and Schieizeth (2013) to illustrate the explanatory power of the developed model. The decision to utilise a mixed effects model instead of a simple regression model was also based on the comparatively higher pseudo-R^2 value of the former. All statistical analyses were conducted in SPSS Version 29.0. Statistical significance was set at $p < 0.05$.

3. Results

3.1. Statistical Summary

Figure 2 illustrates the distribution of three sentiment polarities across nine IEQ factors. The primary sources of dissatisfaction among guests were the facilities of the accommodation, which accounted for 32.03% of the responses, followed by cleanliness and maintenance at 18.24%. Other factors that contributed to guest dissatisfaction included acoustics (7.75%), available space (6.42%), indoor air quality

(4.33%), exterior view (2.92%), lighting (2.22%), thermal environment (2.10%), and layout and design (0.17%).

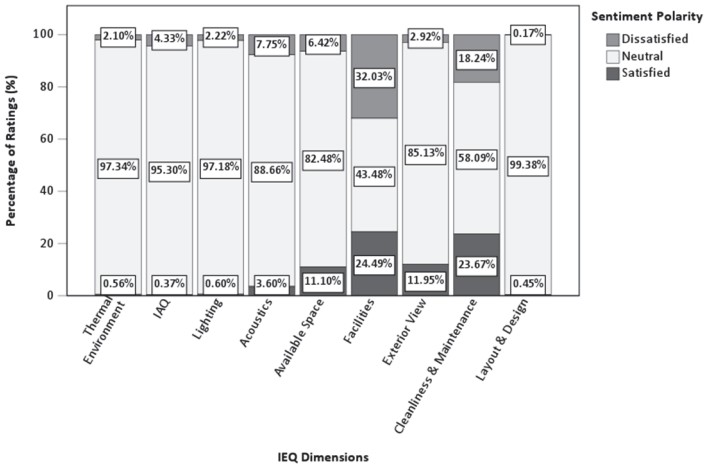

Figure 2 Proportion of three sentiment polarity scales in nine IEQ factors (Source: Zhang et al., 2023)

Upon examining the assumptions of the mixed effects model, it was discovered that the models' residuals exhibited a slight positive skewness across all three sub-samples of star ratings. Despite this, the homoscedasticity of residual variances and the independence between predictors have been confirmed. Mixed effects models are robust, according to Schielzeth et al. (2020), even if the distributional assumptions are violated. Therefore, we believe that the models are accurate, and the estimates are unbiased.

3.2. Asymmetric effects of IEQ factors

As depicted in Figure 1, IEQ factors can be classified as Basic, Performance, or Excitement Factors by comparing the satisfaction differences between the mid-performance and high-performance groups to those between the mid-performance and low-performance groups. The former is represented by the HP group regression coefficient b_x and the latter by the LP group regression coefficient $b_{x'}$ in the mixed effects model. An IEQ factor is categorised as an Excitement Factor if the magnitude of b_x is greater than that of $b_{x'}$, as a Basic Factor if otherwise, and as a Performance Factor if the magnitudes of b_x and $b_{x'}$ are comparable. The 150% difference criterion proposed by Kim and de Dear (2012) was utilised to determine if the two regression coefficients are comparable. If the magnitude of b_x exceeds 150% of the magnitude of $b_{x'}$ for an IEQ factor, that factor is considered an Excitement Factor. If, however, the magnitude of $b_{x'}$ exceeds 150% of the magnitude of b_x, then this IEQ factor is categorised as a Basic Factor. The IEQ factor is classified as a Performance Factor if neither of the conditions are met.

Table 3 presents the regression coefficients pertaining to nine dummy variables representing low and high IEQ performance. These coefficients were derived from three mixed effects models constructed to analyse accommodations with varying star ratings. The discrepancies between cities, tourist origins, and time of travel have been adjusted in these models. In Table 3, when the regression coefficient for the LP group achieved statistical significance but the regression coefficient for the HP group did not, the

corresponding IEQ factor can be identified as a Basic Factor without applying the 150% difference criterion. This is because overall satisfaction in the low-performance group was significantly lower than in the mid-performance group, but there was no significant difference between the mid-performance and high-performance groups. This characteristic corresponds to the definition of a Basic Factor; failure to meet the needs induces dissatisfaction, whereas meeting the needs does not guarantee satisfaction. In other instances, ratios between the magnitude of regression coefficients for the LP and HP groups were computed to assess the classification of an IEQ factor using the 150% difference criterion. The findings indicated that, except for the exterior view, all other IEQ factors were classified as Basic Factors across tourist accommodations with different star ratings. The exterior view played a role as an Excitement Factor in lower-end hotels and serviced apartments, functioning as a Performance Factor in middle-level guest homes, and serving as a Basic Factor in higher-end tourist lodgings.

Table 3: Regression coefficients for nine IEQ dummy sets in the mixed effects model for tourist accommodations with various star ratings while controlling for cities, nationality, and time of travel

Star Rating	IEQ factors	Low IEQ Performance	High IEQ Performance	Ratio (magnitude of LP/HP)	Three Factor
3 Star and below	Thermal Environment	-0.314***	0.046n.s.	—	Basic
	Indoor Air Quality	-1.217***	0.297n.s.	—	Basic
	Lighting	-0.222***	0.120n.s.	—	Basic
	Acoustics	-0.637***	0.262***	2.43	Basic
	Available Space	-0.488***	0.248***	1.97	Basic
	Facilities	-0.715***	0.030n.s.	—	Basic
	Exterior View	-0.285***	0.513***	0.56	Excitement
	Cleanliness & Maintenance	-1.420***	0.473***	3.00	Basic
	Layout & Design	0.040n.s.	-0.054n.s.	—	—
4 Star	Thermal Environment	-0.423***	0.102**	4.15	Basic
	Indoor Air Quality	-0.987***	0.103n.s.	—	Basic
	Lighting	-0.328***	0.090*	3.64	Basic
	Acoustics	-0.715***	0.223***	3.21	Basic
	Available Space	-0.445***	0.256***	1.74	Basic
	Facilities	-0.619***	0.050***	12.38	Basic
	Exterior View	-0.543***	0.380***	1.43	Performance
	Cleanliness & Maintenance	-1.292***	0.356***	3.63	Basic
	Layout & Design	-0.422***	0.206***	2.05	Basic
5 Star	Thermal Environment	-0.423***	0.051n.s.	—	Basic
	Indoor Air Quality	-0.919***	0.107n.s.	—	Basic
	Lighting	-0.192***	0.057n.s.	—	Basic
	Acoustics	-0.687***	0.174***	3.95	Basic
	Available Space	-0.415***	0.173***	2.40	Basic
	Facilities	-0.589***	0.104***	5.66	Basic
	Exterior View	-0.647***	0.347***	1.86	Basic
	Cleanliness & Maintenance	-1.284***	0.338***	3.80	Basic
	Layout & Design	-0.328***	0.096n.s.	—	Basic

(***: $p < 0.001$; **: $p < 0.01$; *: $p < 0.05$; n.s.: not significant)

3.3. IEQ contribution to the overall satisfaction

According to Nakagawa and Schieizeth (2013), the variance explained by the fixed factors is considered by the marginal R^2, whereas the variance explained by both the fixed and random factors is considered by the conditional R^2. Table 4 listed the marginal R^2 and conditional R^2 measures for three mixed effects

models. In the context of hotels and serviced apartments with 3 stars or lower, the combined fixed and random impacts of IEQ factors were found to account for 32.7% of the variations observed in guests' overall satisfaction with these establishments. It is noteworthy that the explained variance attributed to IEQ factors exhibited the highest proportion in lower-end accommodations but shown a gradual decline in middle-level (27.4%) and higher-end guest residences (23.8%).

Table 4: Pseudo-R^2 Measures for mixed effects models

Star Rating	Pseudo-R^2 Measures	Values
3 Star or Below	Marginal	0.215
	Conditional	0.327
4 Star	Marginal	0.201
	Conditional	0.274
5 Star	Marginal	0.188
	Conditional	0.238

4. Discussions

4.1. Comparison with previous studies

Table 3 supports the applicability of the Three-Factor Theory in explaining the IEQ impacts on guest ratings of tourist accommodations. All IEQ factors apart from the exterior view acted as Basic Factors. The absence of these factors has been found to result in dissatisfaction and lower ratings of the premises. The inclusion of a quality exterior view was considered a bonus feature in lower-tier accommodations, however, regarded as an essential feature in higher-end hotels and apartments. This is understandable as customers would have elevated expectations towards luxury hotels and apartments for which they are paying.

Based on the absolute value of the regression coefficients provided in Table 3, Table 5 displays the top four IEQ factors ranked by their impacts on guests' overall satisfaction. The ranking has been conducted separately for situations where the perceived IEQ was unsatisfactory and satisfactory. When guests perceived the IEQ factors to be unsatisfactory, the primary contributors across all star ratings were cleanliness and maintenance, indoor air quality, and acoustics. When IEQ performance was perceived to be satisfactory, the top contributors across all star ratings would be exterior view, cleanliness and maintenance, acoustics, and available space. To avoid receiving a low rating, hospitality managers must ensure satisfactory performance in all IEQ factors, with a particular focus on cleanliness and maintenance, indoor air quality, and acoustics as they are the top dissatisfiers. Based on their respective ranks in the LP and HP groups, exterior view and available space were more influential in eliciting satisfaction than dissatisfaction, although available space was a Basic Factor, as was exterior view in 5-star buildings.

Table 5: Top four IEQ factors that have contributed to the overall satisfaction / dissatisfaction in both low and high IEQ performance groups

Star Rating	Rank	Low IEQ Performance	High IEQ Performance
3 Star and below	1	Cleanliness & Maintenance	Exterior View
	2	Indoor Air Quality	Cleanliness & Maintenance
	3	Facilities	Acoustics
	4	Acoustics	Available Space
4 Star	1	Cleanliness & Maintenance	Exterior View
	2	Indoor Air Quality	Cleanliness & Maintenance
	3	Acoustics	Available Space
	4	Facilities	Acoustics
5 Star	1	Cleanliness & Maintenance	Exterior View
	2	Indoor Air Quality	Cleanliness & Maintenance
	3	Acoustics	Acoustics
	4	Exterior View	Available Space

The results of this study are generally consistent with the findings of prior research. In the study conducted by Li et al. (2020), an examination was carried out on five hotel attributes, namely *cleanliness*, *location*, *room*, *service*, and *value*. The findings revealed that these attributes were all Basic Factors for mid-range and high-end hotels. However, some attributes became Performance or Excitement Factors for budget hotels. While these five attributes encompass broader domains than indoor environment, it is evident that the attributes of *cleanliness*, *room*, and *service* exhibit some overlap with IEQ. Therefore, the results generally agreed with the current study.

4.2. Implications for building design and management

The present study provided strong empirical evidence that demonstrates the substantial influence of IEQ on the overall satisfaction of travelers in guest homes. Most IEQ factors have been recognized as crucial prerequisites by guests, thus they must be performing adequately to achieve satisfaction. The importance of IEQ is particularly pronounced in budget hotels and apartments rated three stars or lower, as it constitutes approximately one-third of guests' overall satisfaction with the establishment. When guests opt for more luxurious accommodations, such as those with 4 or 5-star ratings, their expectations regarding the quality of the buildings and rooms they occupy are elevated. Consequently, the importance of IEQ reduces in relation to their overall satisfaction. Nevertheless, even in luxury hotels and serviced apartments with 5 stars, IEQ remains a significant factor, contributing to approximately one-fourth (23.8% as shown in Table 4) of their overall satisfaction.

The individuals tasked with making resource allocation decisions in retrofitting the built environments, including building managers, architects, and service engineers, rely on their subjective assessment of the significance of different IEQ factors. According to a study conducted by Roumi et al. (2023), building professionals may possess divergent perspectives regarding the relative importance of different IEQ factors. To establish rational priorities, it is imperative for professionals to possess a comprehensive understanding of the effects that different IEQ factors have on occupant satisfaction. This holds particular

significance in situations where there are constraints on the resources that are accessible. In this manner, the allocation of scarce resources can be directed towards the IEQ factors that hold the greatest significance in achieving overall satisfaction.

Managers of hotels and serviced apartments with different star ratings should also formulate tailored strategies to effectively cater to the diverse expectations of their customers. Optimising all IEQ factors may not be as advantageous for budget accommodations as achieving satisfactory performance across all IEQ factors while exceeding customer expectations in one Excitement Factor. The presence of Excitement Factor elicits a delight among customers and may result in higher levels of satisfaction and loyalty.

4.3. Limitations of the study

The present study employed web-mining and NLP methodology for data collection and processing. Consequently, it is important to acknowledge the inherent limitations associated with text-mining approaches. The primary constraint would be the classification accuracy of IEQ factors. Despite our efforts to eliminate sentences containing the appropriate keywords but incorrect contextual information, there remain extraneous phrases within the database that have compromised the precision of subsequent analyses. Future studies may adopt more advanced techniques to improve the classification accuracy and remove irrelevant phrases.

This study exclusively examined the impact of IEQ factors on guests' overall satisfaction. According to previous hospitality studies, there are non-IEQ attributes that will significantly affect overall satisfaction, such as location, price, staff attitude, quality of food, among others. Subsequent investigations may consider these significant attributes in the models to enhance the modelling precision of IEQ factors.

This study lacks the differentiation of hotel guests based on their demographic characteristics, such as gender, age, and education. Subsequent research endeavours may investigate the potential presence of moderating influences contingent upon the demographic composition of tourists.

5. Conclusion

To examine the asymmetric impacts of IEQ factors on guests' rating scores, we employed the Three-Factor Theory of customer satisfaction and utilised mixed effects models. Results showed that factors related to IEQ, except for exterior view, were found to be Basic Factors. This implies that customers would expect the performance of these factors should be satisfactory. Failure to meet these requirements would consequently lead to dissatisfaction. The exterior view of accommodations served as an Excitement Factor in establishments with a rating of 3 stars or lower, as a Performance Factor in those with a rating of 4 stars, and as a Basic Factor in 5-star guest homes. The relative importance of IEQ factors was contingent upon their respective levels of performance. When the IEQ performance was considered satisfactory, the most influential factors were exterior view, cleanliness and maintenance, and acoustics. Conversely, when the IEQ performance was deemed unsatisfactory, the most influential factors were cleanliness and maintenance, indoor air quality, and acoustics. The findings of this study highlight the importance of allocating resources towards improving IEQ in tourist accommodations to enhance customer satisfaction.

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