Article

Assessment of Indoor Environmental Quality in Budget Hotels Using Text-Mining Method: Case Study of Top Five Brands in China

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Abstract: Guests' evaluation of indoor environmental quality (IEQ) is important for identifying environment quality problems in hotels and improving service quality. This paper aims to identify IEQ problems in budget hotels in China and improve them. Specifically, 2.06 million online reviews of budget hotels were used to assess IEQ issues in China's budget hotels in four areas: acoustic environment, luminous environment, indoor air quality (IAQ) and thermal environment. The influences of the season, region and type of customers on the IEQ evaluation were also explored, and the main causes of IEQ problems were also identified. The research results show that the IEQ complaint rates of budget hotels are relatively high. In particular, complaints about the acoustic environment are more common. Differences in seasons and climate zones have significant effects on complaints about the acoustic environment, thermal environment and IAQ. Different types of customers have different concerns about hotel IEQ, among which solo travelers and traveling couples have higher requirements for IEQ. The occurrence of IEQ problems significantly reduces a hotel's online rating, with IAQ and the thermal environment having the greatest impacts, but the causal factors that trigger IEQ problems are relatively concentrated. The findings of this paper can provide a reference for assessing IEQ problems in hotel buildings and guide hotel managers to adopt targeted IEQ improvement programs to promote sustainable development in the hotel industry.

Keywords: budget hotel; hotel sustainability; environmental assessment; indoor environmental quality; text mining

1. Introduction

A very important function of a building as a shelter is to provide users with comfortable indoor environmental quality (IEQ), which is also the most basic requirement for a building. Studies have shown that IEQ problems in buildings have a huge impact on the comfort, health and productivity of their occupants [1–4]. Therefore, in order to improve the IEQ of a building and increase the satisfaction of residents, it is necessary to better evaluate user perceptions of IEQ [5].

Although the indoor environment of buildings has attracted much attention in recent years due to its impact on residents' comfort, previous studies on IEQ have mainly focused on office, classroom or residential buildings [6–11]. Research on the perception of IEQ by hotel customers is relatively rare. Improving the hotel environment is an important way for hotels to improve guest satisfaction and thus increase their profits. IEQ is one of the factors that affects customer satisfaction. Good IEQ can reduce user complaints by improving the working environment [12]. However, due to improper lighting, acoustics, thermal factors and indoor air quality (IAQ), many customers mention IEQ problems when they complain about hotels. This shows that unfavorable IEQ will have a negative impact on travelers'

accommodation experiences, which will affect their overall satisfaction. A few scholars have studied the IEQ of five-star hotels. For example, Qi et al. [13] and Suh et al. [14] analyzed the IEQ issues in five-star hotels in China and South Korea. However, there is a lack of attention toward the IEQ of fast-growing budget hotels. In fact, the nature of budget hotels determines that they are very different from luxury hotels. On the one hand, the high-end attributes of five-star hotels determine that their IEQ is better than that of budget hotels, whose main attributes are being low-cost and cost-effective. Therefore, using only five-star hotels as the research object cannot truly reflect the overall situation of the hotel industry's IEQ. On the other hand, five-star hotels are geared toward high-end customers and their influence groups are limited, while the larger scale budget hotels for the general public clearly have stronger social representation. Therefore, recognizing and understanding customers' attention to the IEQ of budget hotels is essential for the sustainable development of the entire hotel industry.

The research goal of this paper is to investigate the complaints about IEQ in budget hotels with the help of online review data and text mining technology. In addition, this research explores the different factors that affect the IEQ complaint rate. Understanding these different factors and their relationships with IEQ complaints will contribute to the effective design, operation and maintenance of budget hotels. Corresponding to these research objectives, there are five research questions addressed in this paper:

1. How can the content of IEQ complaints be extracted from online reviews?
2. What is the overall situation of budget hotel customers' complaints about IEQ? How serious is each type of IEQ problem?
3. What are the sources of IEQ complaints? What are the differences in IEQ complaints between different seasons, zones, customer types and hotel brands?
4. What is the relationship between IEQ complaints and customer satisfaction? What is the degree of influence of different IEQ factors?
5. How can the IEQ of budget hotels be improved to enhance their competitiveness?

The conclusions drawn by addressing the above issues can provide a reference for improving the indoor environmental quality of hotels and promoting sustainable development of the hospitality industry.

2. Literature Review

This paper mainly focuses on the literature review of both IEQ concerns and the application of online textual information referring to hotel research.

2.1. IEQ Factor for Hotels

IEQ problems have been studied in hotel buildings, but most of them were analyzed for a certain type of IEQ problem. For example, Asadi et al. [15] and Kuo et al. [16] 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. Chan et al. [17] conducted field tests on eight hotels in the Pearl River Delta region of China and found that the IAQ problems of newly built hotels were much more serious than those of old hotels. Chang et al. [18] 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 guest was indoors for activities, PM pollution would increase. Jablonska and Trocka-Leszczynska [19] aimed at the hotel noise problem and put forward the idea of combining a good building system structure with the best acoustic effect to improve the hotel's acoustic environment quality. Sahid et al. [20] used a questionnaire survey method to analyze the indoor thermal comfort of international standard hotel rooms and showed that solar radiation had an important influence on the change of the hotel room's thermal comfort temperature. From the above review, it can be seen that comprehensive research on IEQ issues is still lacking.

In terms of research objects, most of the existing research is aimed at relatively high-end hotels, but there is no research specifically aimed at the IEQ problems of budget hotels.

Generally speaking, budget hotels occupy the most dominant position of all hotel types. Statistics released in the Hotels 325 Special Report [21] showed that more than half of the world's top ten hotel brands belonged to the budget hotel category, and half of them were located in China. Compared with other types of hotels, budget hotels have low prices but limited services and operate in accordance with the principles of economies of scale and standardization [22]. Although the operation of budget hotels is standardized, in the face of fierce market competition, how to adapt to customer needs is an urgent problem that budget hotels need to solve [23]. Therefore, for budget hotels, it is important to understand the driving factors of different customer behaviors and service satisfaction [24,25].

2.2. Application of Online Reviews

The online hotel booking platform offers a wide range of online review texts. Travelers will express their preferences through text comments based on their views on hotel standards [26]. Customers increasingly rely on online reviews for hotel information in order to make an informed accommodation decision. Travelers may also change their minds after reading online reviews from other travelers [27]. Online hotel reviews are considered to be efficient and low-cost. The rapid development of big data technology provides a huge opportunity for in-depth research on people's satisfaction and perception through online reviews. For example, a method called text mining allows researchers to use online tools to evaluate customers' opinions on the subject of a review [28]. More and more studies have highlighted the determinants of customer satisfaction [29–31] and dissatisfaction [32–34] by analyzing online reviews.

Online reviews provide the possibility of mining IEQ complaints. The survey found that customers were more inclined to pay attention to online reviews, especially negative reviews [35], when choosing accommodations and hotels online. Obviously, too many IEQ complaints will have a negative impact on hotels. Therefore, exploring a hotel's IEQ problems and proposing targeted improvement measures is of great significance for improving customer satisfaction and hotel marketing management. In the last decade, online reviews have been widely used in hotel research, though there are not many examples of research on hotel IEQ using online reviews. Qi et.al. [13] and Villeneuve and O'Brien [36] studied the IEQ of five-star hotels in Chinese and Canadian hotels, respectively, and reached similar conclusions. The IEQ complaint rate for five-star hotels in China was 4%, and the complaint rate for Canadian hotels was 4.8%. Abdulaali et al. [37] used online reviews to analyze the frequency of IEQ complaints for green-certified hotels in Kuala Lumpur, Malaysia and the potential reasons that affected the comfort and satisfaction of hotel guests. However, they only obtained 3836 reviews of three green-certified hotels.

Customer perception of IEQ is a complex and dynamic concept, and it will vary according to the person, time and location [38]. However, the existing research lacks in-depth analysis of the different factors that affect the perception of IEQ. For example, Villeneuve and O'Brien [36] considered the relationship between IEQ categories and the seasonal trends of IEQ issues, but they did not consider the differential impacts of customer types and regions. In fact, more information can be extracted from online reviews, such as the differences in IEQ complaint rates between different brands, different customer types and different zones. This allows us to study the hotel's IEQ more deeply, but existing studies have not fully exploited this information.

3. Materials and Methods

Online evaluation has been found to play an important role in hotel reservations [39]. With the rapid development of web technology, travelers increasingly tend to book hotels online. A standard online booking website encourages travelers to express their opinions and experiences, resulting in millions of unique reviews on all these sites. A large number of online web-based reviews provided rich textual material for our study.

The process of collecting and processing online text data for budget hotels, as well as the identification and analysis of IEQ reviews, is outlined in Figure 1.
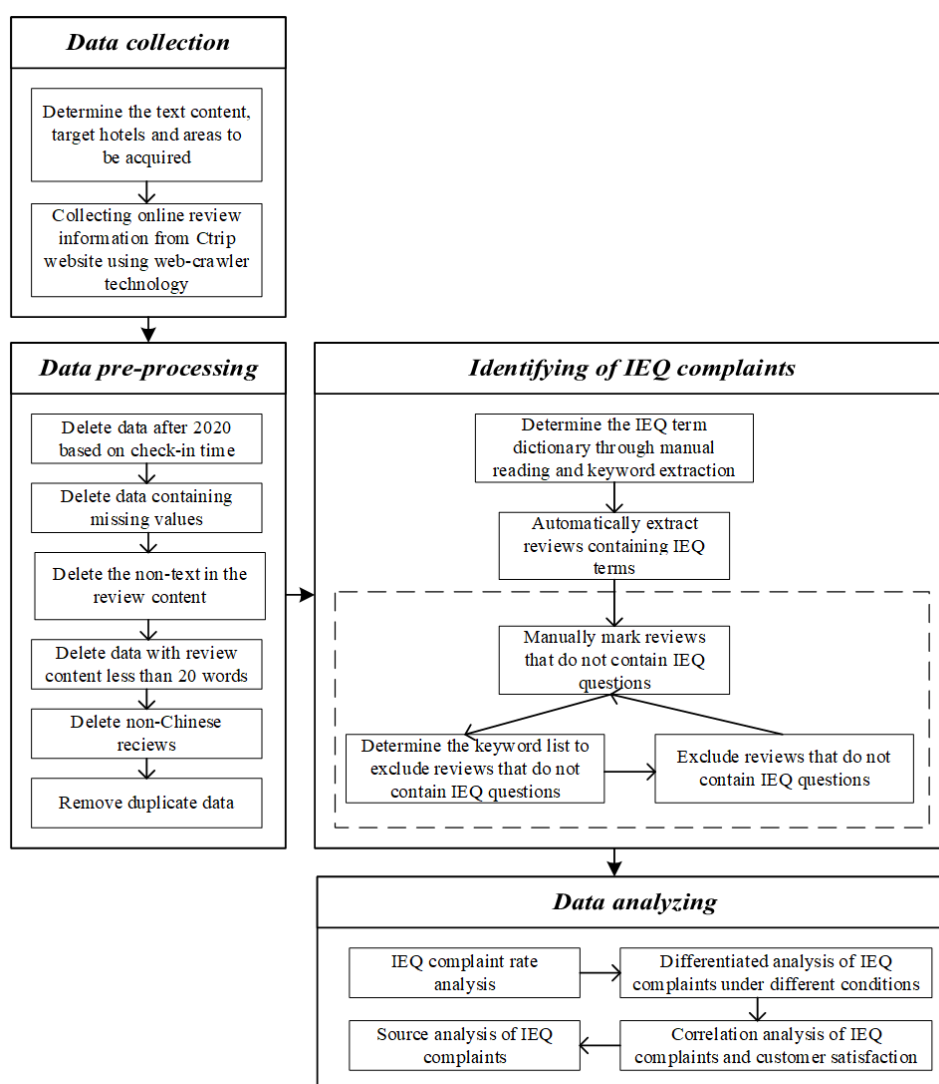
Figure 1. The process of collecting, preprocessing, identifying and analyzing IEQ complaint data.

3.1. Data Collection

The data in this paper were collected from Ctrip.com, which was launched in 1999 and listed on the Nasdaq in the US in December 2003. Ctrip.com was chosen because it is China's largest online hotel reservation website. Survey data showed that Ctrip.com occupied a 47.9% transactional market share of China's online accommodation market in Q1 2019, ranking first [40]. Ctrip.com allows guests to write open-ended reviews after their stays, and the data used in this paper were derived from the open information of these reviews.

In order to ensure the collected data were representative, the online review data were collected from the top five budget hotels in China in terms of market share in 2019, namely Hanting Hotel (HT), Home Inn (HM), 7 Days Inn (7D), Green Tree Inn (GT), and Jin Jiang Inn (JJ), with a combined market share of nearly 40% [41]. For the sake of comparative analysis, the budget hotels selected were from 35 large and medium-sized cities in mainland China, including 30 provincial capital cities (excluding Lhasa) and 5 sub-provincial cities (Dalian, Qingdao, Ningbo, Xiamen and Shenzhen). These cities cover different regions of mainland China and allowed analysis of the impact of diversified external environments on IEQ.

Web-crawling techniques were used to obtain online review information for this paper. Web-crawling is a technology that automatically collects the required information

from one or more pages based on a certain strategy, and it is a way to access network resources through a simulated browser [42]. Based on Octopus V8.1.16 (mature web-crawler software), 2.06 million online reviews of 4051 budget hotels published from June 2016 to June 2020 were collected from Ctrip.com. The collected content is shown in Figure 2, including the hotel name, hotel address, resident rating, review content, guest type and check-in time.

Figure 2. Example of information collected from Ctrip's online review data.

3.2. Data Preprocessing

To ensure the validity of the data, the collected data were preprocessed. First, the data after 2020 were removed, mainly due to the consideration that since the COVID-19 outbreak, some hotels have not allowed their air conditioning to be turned on to prevent the spread of the virus, which could have an impact on the thermal environment experiences of customers. In addition, hotels may spray disinfectant to prevent viral growth, which can also result in a poor air quality experience. The effects brought by COVID-19 are unconventional, and these data were removed in order to eliminate this impact. Secondly, some data with missing content were deleted to prevent the accuracy of the statistics being affected by missing content. Third, the text of online comments' content containing only expressions and special characters, which cannot directly provide valuable information, was deleted. English comments were also removed in this process, mainly because English expressions are slightly different from Chinese expressions and may not express the real perceptions of customers if translated directly into Chinese. Fourth, online reviews with fewer than 20 characters were also removed, because relevant studies have shown that content with fewer than 20 characters provides limited useful information [43]. Finally, duplicate online review data were removed because they may have been duplicate reviews made intentionally by someone for some purpose, and they may not necessarily be the true expression of the customer while also affecting the accuracy of the analysis.

After preprocessing, a total of 680,150 pieces of data were eligible for further analysis. The details of the online reviews of the five branded budget hotels collected for this paper are shown in Table 1.

Table 1. Summary of the online review information for five branded budget hotels.

Hotel Brand	Number of Hotels	Results of Data Processing	
		Raw Data	Valid Data
HM	981	550,143	171,094
7D	1005	618,282	211,722
HT	1296	473,637	159,578
JJ	313	316,623	105,319
GT	456	107,677	32,437
Total	4051	2,066,362	680,150

3.3. Identification of IEQ Complaints

Once the online comment data were available for analysis, it was necessary to further identify the textual content relevant to IEQ complaints, as described in the next three subsections.

3.3.1. Compile IEQ Term Dictionary

This paper systematically evaluates the IEQ of budget hotels in four dimensions: acoustic environment, IAQ, thermal environment and luminous environment, with reference to the classification of China's Green Building Evaluation Standard (GB/T50378-2014).

Some guests may not have used scientific IEQ terms but more common phrases for online reviews, so it was not possible to accurately mine IEQ-related text by relying on specialized terms alone, and for this reason, this paper further employed a manual screening method to identify keywords for text mining. By reading guests' reviews, keywords used by guests to express the relevant terms of IEQ were selected based on the authors' understandings and experiences of the IEQ factors. Considering the possible variability of IEQ in different hotels and cities, a random method was used to select 2000 reviews for each brand hotel, and a total of 10,000 reviews were read. To ensure the accuracy of keyword selection, two rounds of screening were conducted in this study, first by the second author of this paper and then by the first author, who then repeated the reading to prevent any omission or incorrect selections.

Text mining with Chinese is very difficult, because there can be many linguistic expressions with the same meaning. For example, if a customer wanted to express "poor sound insulation", they might comment "very poor sound insulation", "somewhat poor sound insulation", "relatively poor sound insulation" or many other expressions. In order to identify these comments as comprehensively as possible, this paper used regular expressions in computer science to automatically mine the text that matched our determined keyword expression rules. Table 2 shows the main keyword entries for each IEQ factor.

Table 2. The main keyword entries for each IEQ complaint category.

IEQ Category	Phrases of IEQ Complaint
Acoustic environment	poor sound insulation, bad sound insulation, no sound insulation, very noisy, relatively noisy, a little noisy, loud noise, severe noise, audible noise, some noise, loud voice
Luminous environment	dim, dark, very dark, relatively dark, dark room, poor lighting, no sunlight, no light source, not bright, opaque, broken lamp
IAQ	peculiar smell, smoke smell, musty smell, sewage smell, big smell, heavy smell, decoration smell, unpleasant smell, poor ventilation, no ventilation, airtight, poor air, bad air
Thermal environment	cold, very cold, freezing, too hot, awake from heat, a little hot, very hot, stuffy, wet, damp, very dry, relatively dry, no heating, poor heating, not warm, insufficient heating, faulty air conditioner, no air conditioner

3.3.2. Extracting Reviews Containing IEQ Problems

Text mining was used to extract content related to IEQ. Text mining, also known as intelligent text analysis, text data mining or knowledge discovery in text (KDT), generally refers to the process of extracting interesting and nontrivial information and knowledge from unstructured text (such as emails, full-text documents and HTML files) [44]. With the help of text-mining tools, specific documents could be retrieved and preprocessed by checking the format and character set before being subjected to a text analysis process to obtain high-quality information, which in turn generated a large amount of knowledge for the user. In this study, the R-based text-mining toolbox of the Rstudio platform was used for online text mining, focusing on the "stringr" package for R, an easy-to-use string toolset. This toolset contains a large set of built-in character processing functions for matching, extracting, splitting, gluing, replacing strings and more.

3.3.3. Identification and Deletion of Irrelevant Reviews

Chinese expressions are relatively complex compared with other languages. Very similar or even the same expressions may express completely different meanings in different contexts, which will reduce the accuracy of comment extraction. For example, "hot" is a keyword in a thermal environment, but if "hot" is extracted directly, the word "enthusiastic" in the Chinese expression "the waiter is very enthusiastic" will probably be extracted, although it is obvious that the word has nothing to do with the thermal environment. Another example is that "odor" is a complaint about air quality, but when the keyword "odor" is used to extract a comment phrase, the phrase "no odor" will also be extracted, which will have an impact on the accuracy of identifying IEQ complaints.

To eliminate the impact of irrelevant comments, the text content extracted from the initial set of keywords was read, and then the keywords that were not related to IEQ complaints were filtered out. Then, the character removal function of the R program was used to exclude the irrelevant comment data. After several rounds of deletion, the final accuracy rate for extracting IEQ complaint data was over 90%.

3.4. Data Analysis

3.4.1. Measurement of IEQ Complaints

In order to visualize the IEQ complaints of budget hotels, Equation (1) was used to characterize the complaint rate index:

$$\text{IEQ Complaint rate} = \text{Number of complaints about a certain IEQ comments}/\text{Total number of comments} \qquad (1)$$

In Equation (1), the numerator is the number of reviews containing IEQ problems, and the denominator is the total number of corresponding valid reviews.

3.4.2. Analysis Dimensions of IEQ Complaints

Combining the online textual comments collected and the measure constructed by Equation (1), this paper analyzes IEQ complaints from several aspects. First, the current situation of IEQ complaints was analyzed, including the overall situation of the sample hotels collected for this paper and the complaints of different hotel brands and different IEQ types. Secondly, we analyzed the variability of IEQ complaints due to different climate regions, seasons and customer types by combining the information collected on the city of stay, the time of stay and the type of customer after the necessary processing. Finally, the quantitative relationship between the hotel IEQ complaint rate and customer satisfaction were analyzed by combining the online rating data for the hotels. In addition, the sources of IEQ complaints were also analyzed to explore strategies to improve IEQ satisfaction.

4. Results and Discussion

This section presents the results of the study in relation to four aspects: the complaint rate of IEQ problems in Chinese budget hotels, the variability of the complaint rate under different conditions, the relationship between IEQ complaints and customer satisfaction and the main causes of complaints.

4.1. IEQ Complaint Rate Analysis

This study examines not only the total complaint rate of budget hotels in China, but also the complaint rate for each IEQ problem separately. In addition, the differences in IEQ among the five budget hotels are compared. The detailed results are discussed in detail in the following three subsections.

4.1.1. Overall Analysis of the IEQ Complaint Rate

The overall complaint rate for budget hotels in China was 12.13%. This is clearly much higher than the result of Qi et al. [13] for the IEQ problem of five-star hotels in China (4%). This result shows that the IEQ problem of budget hotels is quite serious.

From the perspective of different brands, their IEQ complaint rates varied greatly, as shown in Figure 3. The horizontal line in the figure is the average complaint rate of the five brands. Among the five brands, GT had the highest IEQ complaint rate, which was much higher than those of the other four brands. The complaint rates of HM and HT both exceeded the average level. Although the complaint rates of 7D and JJ were lower than the average, they also exceeded 10%. The above data show that although there were certain differences in the IEQ complaint rates of budget hotels of different brands, the overall performance was not good. This shows the universality of IEQ problems in China's budget hotels. The differences between different brands also indicate that IEQ problems can be improved through management and service improvements.
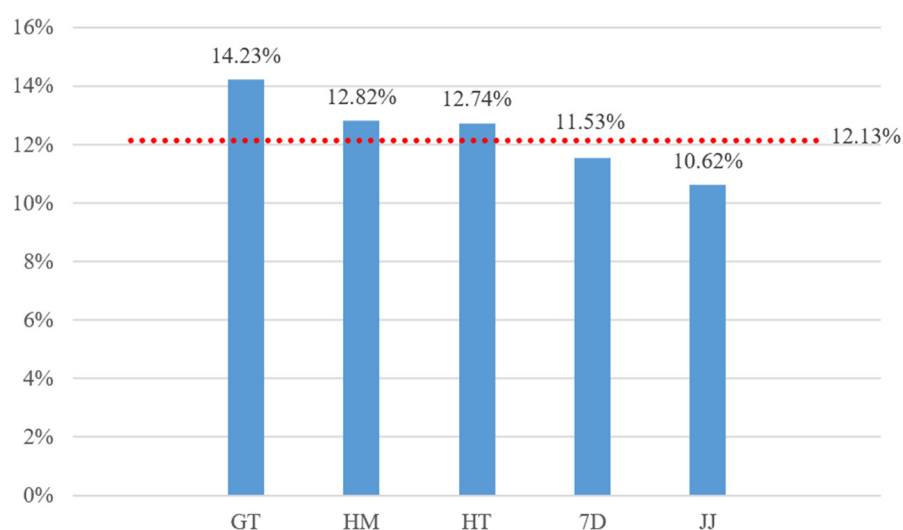

Figure 3. Overall complaint rates of different hotel brands.

4.1.2. Analysis of the Complaint Rates of Different IEQ Categories

As shown in Figure 4, the categories with the highest IEQ complaint rates of China's budget hotels ranked in descending order were the acoustic environment, IAQ, thermal environment and luminous environment.
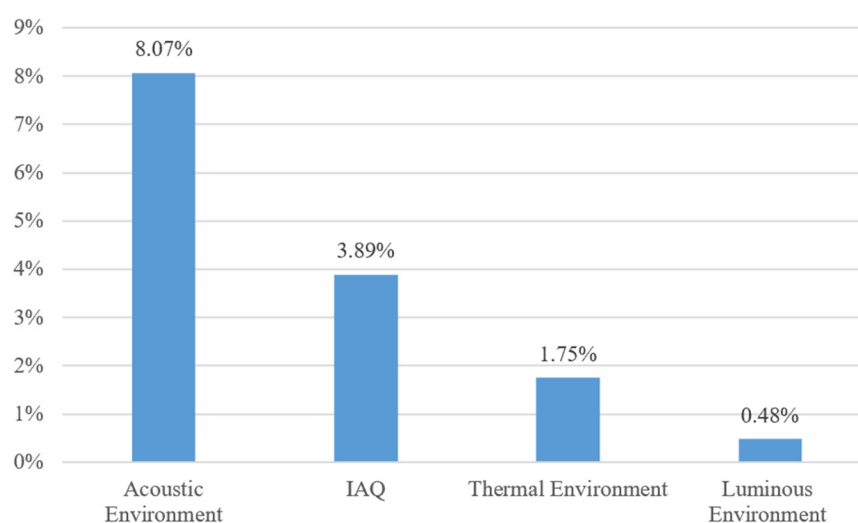

Figure 4. Overall complaint rates of different IEQ categories.

Figure 5 shows the details of the IEQ complaints of the five hotel brands. The IEQ problems of different hotels had commonalities and differences. On the one hand, the

complaint rates of the acoustic environment and IAQ of the five hotel brands were relatively high, which means that they all had a lot of room for improvement in these two aspects. On the other hand, the differences in IEQ problems of the different hotels also indicate that different hotels need to make corresponding changes to their most prominent issues.
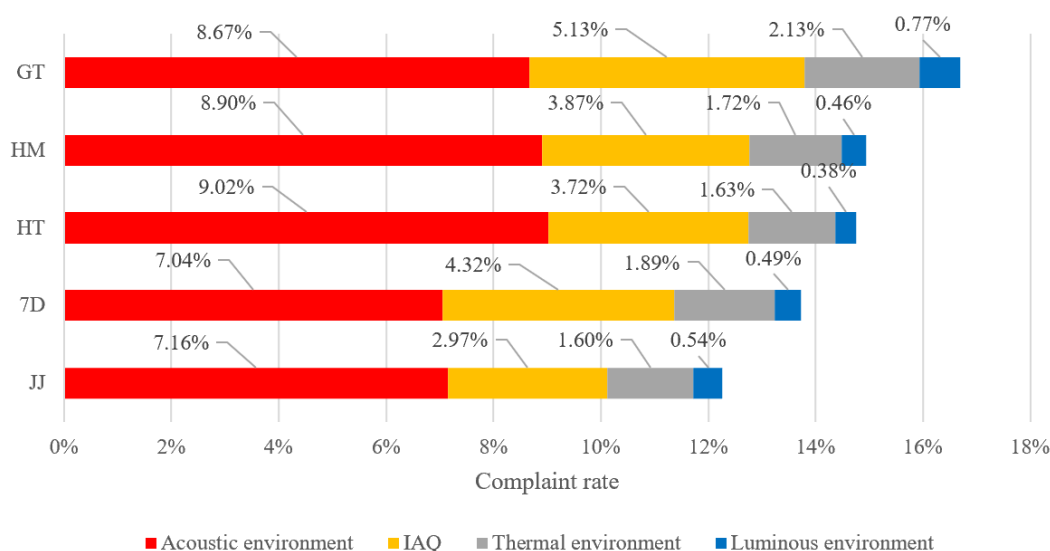

Figure 5. Complaint rates of different IEQ categories of different hotel brands.

The following are the results of analyzing the IEQ problems of China's budget hotels in combination with Figures 4 and 5.

- Acoustic environment

The comfort of the acoustic environment is the state of satisfaction with the acoustic conditions. When any sound begins to exceed the limit of what humans can tolerate, it is perceived as noise [45]. In other words, an inappropriate acoustic environment inside a building will significantly affect the occupants' comfort and satisfaction. The occupants have little control over the noise sources in a building, and the persistence of noise can further challenge the tolerance levels of the occupants, thus making noise a key target of customer complaints.

Figure 4 shows that the complaints about the acoustic environments of budget hotels were the highest in number, reaching 8.07%, which shows that the acoustic environment problems were very serious. Figure 5 shows that HT had the highest complaint rate, reaching 9.02%. The complaint rates of HM and GT both exceeded 8%. The complaint rates for the acoustic environments of the JJ and 7D hotels were relatively low, but still above 7%. This shows that the acoustic environment problem is a common problem for all budget hotels.

- IAQ

IAQ is an indicator to measure the quality of indoor air in a building. It is widely agreed that IAQ affects the health, comfort and productivity of building occupants [46]. In addition, IAQ has a significant impact on living comfort and mood changes. Poor air quality will not only significantly reduce the sleep quality of residents [47] but also cause anxiety and irritability [48]. Therefore, poor IAQ can easily lead to customer dissatisfaction, which in turn will increase the complaint rate.

Figure 4 shows that the overall complaint rate of IAQ was 3.89%, second only to the complaint rate of the acoustic environment. As shown in Figure 5, GT had the highest complaint rate, reaching 5.13%, followed by 7D (4.32%). The complaint rates of HM (3.87%) and HT (3.72%) were relatively close, and the complaint rate of JJ was relatively low (2.97%). It can be seen from the data that different hotels had certain differences in IAQ complaints,

which also indicates that the hotels with high rates of IAQ complaints still have a lot of room for improvement.

- Thermal environment

The impact of the thermal environment on customers is mainly characterized by thermal comfort indicators. Thermal comfort is described as "a mental state that is satisfied with the thermal environment". Thermal comfort is an important factor in creating a comfortable environment and good health for people in buildings [49]. A thermally comfortable environment has a significant impact on sleep quality [50], which is obviously very important for hotel customers.

The overall complaint rate of the thermal environment was 1.75%, as shown in Figure 4, which was relatively low compared with the acoustic environment and IAQ. As shown in Figure 5, only GT had a complaint rate as high as 2.13%, and the complaint rates of the other hotels were around 1.7%. This shows that the thermal environment problem is not serious, but it is common in all hotels.

- Luminous environment

The luminous environment includes natural lighting and artificial lighting. Natural lighting mainly refers to sunlight or outdoor light entering a room through windows, while artificial lighting is mainly provided by lamps. The research of Musa et al. [51] showed that high-quality lighting could improve people's visual comfort and enhance attention, emotion and attitude, while too much direct sunlight and artificial light would produce glare and cause visual discomfort. Therefore, a good luminous environment is one of the important parameters for achieving the comfort and satisfaction of hotel guests.

Figure 4 shows that the complaint rate of the luminous environment was 0.45%, which was the lowest compared with the other environmental factors. From the luminous environment complaint rate of the different hotels (as shown in Figure 5), GT still had a relatively high complaint rate of 0.77% followed by JJ (0.54%), and the other three hotel brands were less than 0.5%. This result shows that compared with other types of IEQ problems, the luminous environment problems were not very serious.

4.1.3. Quantitative Analysis of the Simultaneous Occurrence of Multicategory IEQ Problems

Most of the existing studies only considered the independent influence of IEQ on the perceptions of hotel customers while ignoring the comprehensive influence of the interaction between IEQ factors on customer comfort. In fact, some IEQ factors are mutually restrictive and interdependent. When two indoor environment parameters are used as variables at the same time, a change in one parameter will affect the impact of the other parameter on a guest's hotel environment perception.

In order to explore the prevalence of multiple IEQ complaints in hotel buildings and how they affect each other, a function was written to further evaluate online reviews that contained two or three categories of IEQ problems. Table 3 shows the statistics of the number of reviews containing one or more IEQ problems.

Table 3. Number of comments with one or more categories of IEQ problems.

	Acoustic Environment	Luminous Environment	IAQ	Thermal Environment
Acoustic environment	54,891	547	4118	1896
Luminous environment		3232	478	251
IAQ			26,490	1621
Thermal environment				11,907

Table 3 shows that the three most common category combinations were acoustic environment with IAQ, acoustic environment with thermal environment and IAQ with thermal environment. That means there may be mutual influence between them. Studies

have shown that opening windows has a significant effect on the indoor concentrations of PM, total volatile organic compounds (TVOC) and CO_2 [52,53]. Therefore, occupants tend to improve IAQ by opening or closing windows [54,55]. However, if customers open windows, this may bring noise problems [56], which will negatively affect customers' sleep and other issues. When it comes to the acoustic and thermal environments, an increase in sound pressure will lead to a decrease in satisfaction with the thermal environment, and an increase in temperature will also lead to a decrease in customers' tolerance of noise. For example, studies have shown that when the sound pressure is increased from 60 dB to 75 dB, the acceptability of the thermal environment will be reduced by about 3% [57]. Existing research on the relationship between IAQ and thermal environments shows that the impact between the two is mainly one-way: a higher temperature will have a negative impact on the acceptable degree of IAQ [58]. Little evidence that air quality affects the thermal environment was found in the investigated literature.

Table 4 shows the statistics of the number of comments in which the three types of IEQ occurred simultaneously.

Table 4. Number of reviews with three categories of IEQ problems.

Category	Number
Acoustic, thermal and IAQ	499
Acoustic, visual and IAQ	123
Thermal, visual and IAQ	90
Acoustic, visual and thermal	80
Total	792

The total number of reviews with three types of IEQ complaints occurring at the same time was 792, accounting for about 0.96% of all IEQ complaint texts; that is, about 1 out of every 100 IEQ reviews had three types of IEQ complaints at the same time. This is also a relatively large proportion, indicating that there are some budget hotels with a high possibility of multiple IEQ problems occurring at the same time. Among these, there were 499 comments relating to the acoustic environment, thermal environment and IAQ occurring at the same time, accounting for 63.01% of the comments with three types of IEQ complaints. This phenomenon is relatively easy to understand, because when poorly insulated hotel buildings cause residents to complain about thermal comfort problems, they often also complain about stuffy air due to high temperatures, and poor building construction may also cause poor sound insulation. The number of samples in which the other three IEQ combinations occurred simultaneously was only around 100, indicating that the simultaneous occurrence rates of these combinations were relatively low. This result indicates that for hotel buildings, the focus should be on solving the problem of the simultaneous occurrence of acoustic environment, thermal environment and IAQ issues.

4.2. Differentiated Analysis of IEQ Complaints under Different Conditions

This study comprehensively considered the differences in IEQ complaint rates under different influencing factors such as the season, region and customer type. The results are described in detail in the following three subsections.

4.2.1. Differentiated Analysis of IEQ Complaints in Different Climate Regions

The climate will bring about changes in the outdoor environments of buildings and, as a result, affect the IEQ [59]. China is a large country, and different regions have different climates. In order to study the possible impact of the regional climate on IEQ, this research refers to the regional division standard in the Civil Building Thermal Design Code (GB50176-2016), and according to the temperature conditions, 35 cities were divided into 5 regions, as shown in Figure 6: severe cold, cold, hot summer and cold winter (HSCW), hot summer and warm winter (HSWW) and temperate. The collected reviews came from 4051 hotels located all over China, of which 363 hotels were located in severe cold zones,

1500 hotels were located in cold zones, 1613 hotels were located in HSCW zones, 458 hotels were located in HSWW zones and 117 hotels were located in temperate zones.

Figure 6. Climate zones of 35 different cities.

Figure 7 shows the different complaint rates in the different climate zones. In terms of the total complaint rate, there were large differences between climate zones. In terms of different types of IEQ complaints, the complaint rates of the acoustic environment, thermal environment and IAQ were quite different, which shows that these three types of complaints had obvious regional characteristics.
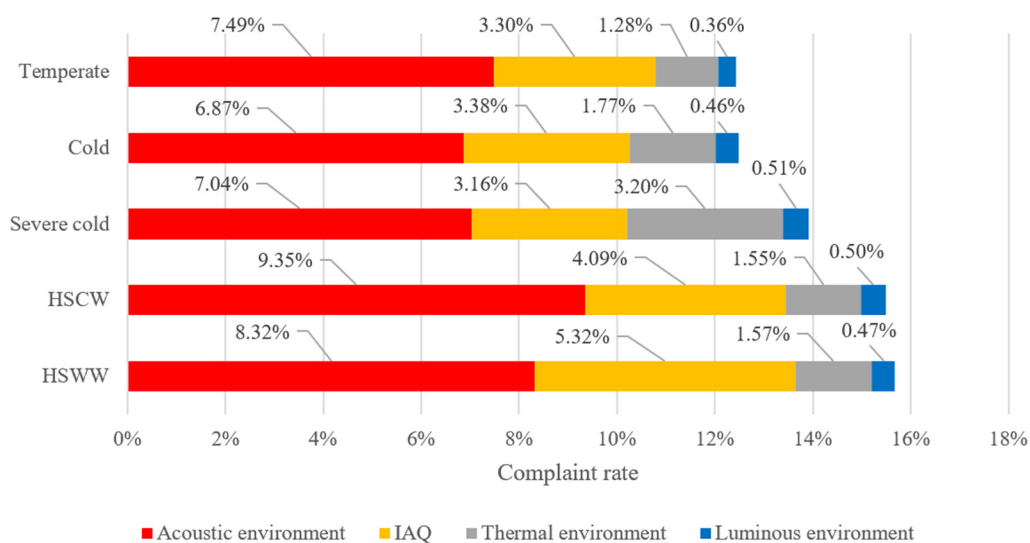

Figure 7. IEQ complaint rates in different climate zones.

Figure 7 shows that the HSWW and HSCW zones had the highest overall complaint rates. This means that in areas with higher temperatures, the IEQ complaint rate was higher. From further analysis of the complaint rates of different types of IEQ, it was found that the complaint rates of the acoustic environment and IAQ in the HSWW and HSCW zones were much higher than those of other zones. On the one hand, the high complaint rate of the acoustic environment may be related to the frequent opening of windows by hotel guests in these areas. On the other hand, it may be related to the decrease in noise tolerance of the customers as the temperature rose [60]. The relatively high rate of complaints about IAQ may be related to high temperatures. High temperatures and humidity are more likely to cause a moldy smell indoors, and high temperatures increase the diffusion of volatile organic compounds. The fact that one third of the IAQ complaints occurred in the summer in these two regions confirms this. What is more interesting is that the complaint rates of the thermal environment in these two zones were relatively low (only higher for the temperate zone). This may be due to the fact that hotels in these regions pay more attention to the use of air conditioning.

Secondly, the total IEQ complaint rate in the severe cold zones was second only to the HSWW and HSCW zones, and the thermal environment complaint rate was much higher than in the other zones. Statistics show that 36.48% of the thermal environment complaints in severe cold areas occurred in the summer and 35.94% occurred in the winter.

The total complaint rates of the IEQ in cold zones and temperate zones were equal. The difference between them was that the thermal environment complaint rate in the cold zones was slightly higher, second only to severe cold zones, but the acoustic environment complaint rate was lower, which may be because the infrequent opening of windows reduced the interference of outdoor noise. The acoustic environment complaint rate in the temperate zones was relatively high, but the thermal environment complaint rate was relatively low. This result is easy to understand. Thermal environment complaints have obvious seasonal characteristics, as excessive cold or overheating will lead to an increase in the complaint rate of the thermal environment. The temperature in the temperate zones is comfortable and pleasant all year round, so there are fewer complaints about the thermal environment, but it may be that windows are frequently opened for ventilation, which may lead to higher acoustic environment complaints.

From the above analysis, it can be seen that regional climate differences had a significant impact on the IEQ complaints of budget hotels. Specifically, budget hotels in HSWW zones and HSCW zones had the highest IEQ complaint rates. In particular, the acoustic environment complaint rate and the IAQ complaint rate were much higher than in other areas. The complaint rate in severe cold zones was also higher, especially the thermal environment complaint rate. The complaint rates of budget hotels in cold zones and temperate zones were lower than those in other zones.

4.2.2. Differentiated Analysis of IEQ Complaints in Different Seasons

The external environment of a building will directly affect the IAQ through the envelope structure. Most areas of China have four distinct seasons, and the climatic conditions in different seasons are quite different. Therefore, this paper put seasonal labels on the data according to the check-in time in order to explore the differences in IEQ complaints in different seasons. According to China's climate characteristics, March, April and May are defined as spring, June, July and August are defined as summer, September, October and November are defined as autumn and December, January and February are defined as winter. Figure 8 shows the seasonal trends of various IEQ problems.
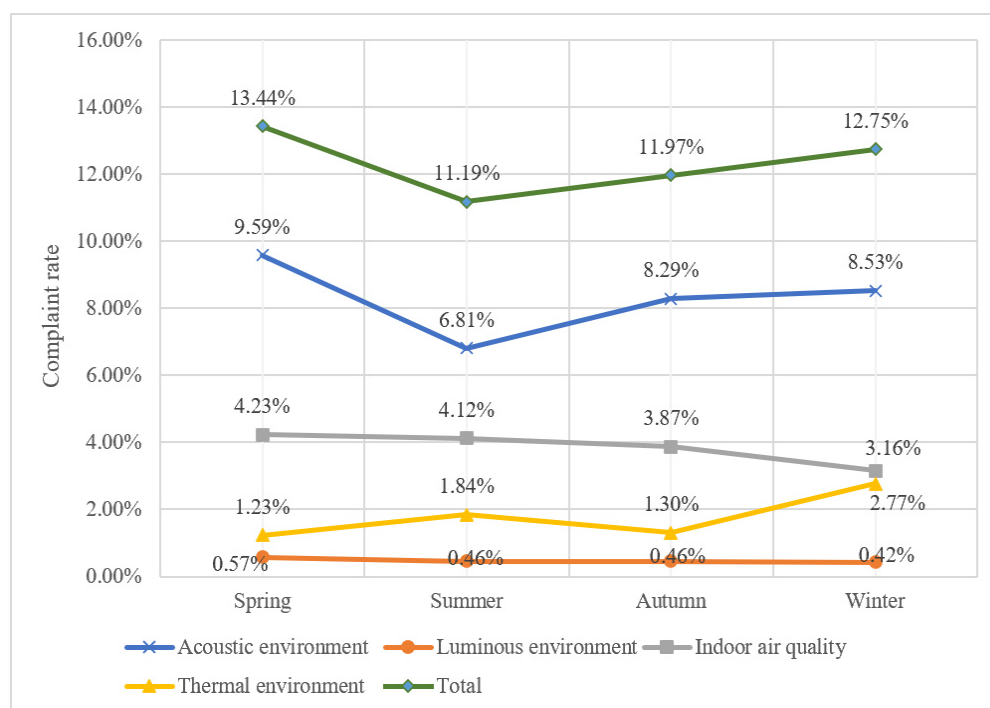
Figure 8. IEQ complaint rates of different seasons.

Figure 8 shows that the total complaint rate in spring was the highest, reaching 13.44%, and the total complaint rate in summer was the lowest at 11.19%. From the seasonal trends, the complaint rates of the acoustic environment, IAQ and thermal environment fluctuated greatly in different seasons, while the trend of the complaint rate of the luminous environment was relatively stable.

Specifically, the acoustic environment complaint rate was highest (9.59%) in the spring and lowest (6.81%) in the summer. The difference between spring and summer may be related to seasonal characteristics. The climate zones in China mainly include a temperate monsoon climate, subtropical monsoon climate and temperate continental climate. In most areas, including some cold regions, air conditioning is required to reduce indoor temperatures in the summer. Closing the windows when the air conditioner is on can reduce a lot of outdoor noise. The temperature in spring is relatively pleasant, mainly handled by opening windows for cooling and ventilation. When opening windows to solve the problems of the thermal environment and IAQ, this will also increase complaints about the acoustic environment. Research by Villeneuve and O'Brien [36] also pointed out that opening windows would cause outdoor noise to enter the room, causing an increase in the acoustic environment complaint rate.

The IAQ complaint rate reached 4.23%, 4.12% and 3.87% in spring, summer and autumn, respectively. However, in the winter, the IAQ complaint rate dropped significantly to 3.16%. On the one hand, this may be related to the low temperatures in winter. Low temperatures inhibit the spread of organic volatiles that release odors and make people less irritable than hot environments. From the conclusion of Section 4.2.1, high temperature areas had the highest IAQ complaint rate, and severe cold zones had the lowest IAQ complaint rate. The conclusion of this section also confirms the conclusion that high temperatures will increase the IAQ complaint rate and low temperatures will reduce the IAQ complaint rate. On the other hand, the low complaint rate in winter may also be related to people's psychological expectations. Winter is the worst season for outdoor air quality in China. Poor outdoor air will reduce people's expectations of air quality. Therefore, compared with the poor outdoor air quality, people will reduce their IAQ complaints about hotels.

The complaint rate of the thermal environment has a strong relationship with the season because the temperature, the main factor in seasonal differences, is the main cause of thermal environment complaints. From Figure 8, the thermal environment complaint rates in the summer and winter were higher than those in the spring and autumn. This is related to extreme temperatures in the summer and winter. Compared with summer and winter, the temperatures in spring and autumn are relatively mild, so the thermal environment complaint rate is relatively low.

4.2.3. Differentiated Analysis of IEQ Complaints for Different Customer Types

Travelers are usually divided into five categories: business travelers, couples, families, friends and solo travelers [61]. Different types of travelers have different goals and expectations for hotels [62], and their perceptions of IEQ may also be different. When customers share their hotel reviews on online platforms, they tend to talk about aspects that are important to them, which may vary from person to person. Therefore, analyzing the content of online reviews from different types of travelers may yield meaningful findings.

Ctrip's website divides hotel customers into seven types, namely "solo travelers, couples, families, business travelers, friends, booked for others, and other". In the analysis of this paper, two types of customers, "booked for others" and "other", were deleted because the evaluator "booked for others" did not provide a real experience of the hotel's environment and services. For customers whose type was "other", because the type was not clear, their analysis was not meaningful. The number of customers whose types were "booked for others" and "other" were 76,015, and 604,135 reviews remained after their deletion. Figure 9 shows the complaint rates of the five customer types. This result shows that there were significant differences in the IEQ complaints from different customer types.
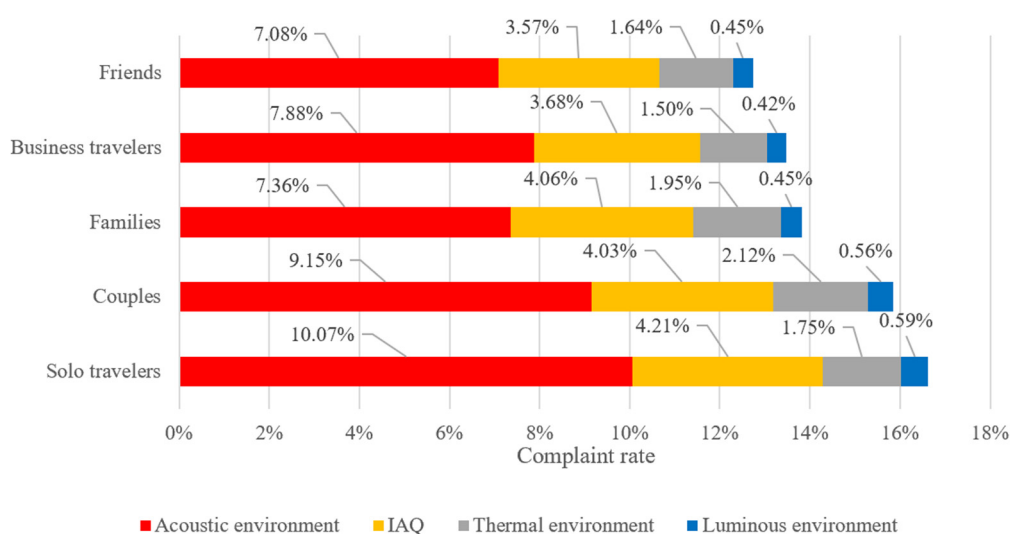

Figure 9. IEQ complaint rates of different customer types.

The reasons that led to differences in customer perceptions of the IEQ may be related to the customer's travel purpose and psychological environment. The travel motivation for solo travelers is to enjoy the journey, so they will be more sensitive to a hotel's IEQ. Traveling couples are more likely to be celebrating a special day and inclined to enjoy life [63], and so they will be more susceptible to sensory attributes such as atmosphere and emotion [64], therefore having higher requirements for hotel IEQ. Friends and families pay more attention to the communication and emotional development between companions, while business travelers pay more attention to the completion of work tasks, the convenience of the hotel location and the availability of the Internet [65]. The hotel's IEQ is not the focus of their attention, which also means their complaints may be fewer.

It can be seen from the table that solo travelers and couples, both with high concern for the IEQ, had higher complaint rates about the IAQ, acoustic environment and luminous environment. The higher complaint rates of couples and families about the thermal environment may be caused by the large difference in temperature perception between men and women.

The differences between different types of travelers' complaints about hotel IEQ have very important practical significance for hotel managers. According to this result, hotel managers should fully consider the different concerns of different types of customers when designing or improving hotels so as to improve customer satisfaction with the hotel as much as possible.

4.3. Correlation Analysis of IEQ Complaints and Customer Satisfaction

Guests can score hotels after check-in to reflect their attitude toward the hotel, so their scores can be used to characterize the degree of customer satisfaction with the hotel. The highest online score is five, and the lowest is one. The higher the score, the higher the customer satisfaction. The calculation results showed that the average score of reviews with IEQ complaints was 3.67, which was lower than the average score of all online reviews collected (4.40). This shows that IEQ complaints will significantly lower the customer's rating of the hotel.

To further explore the relationship between customer satisfaction and the complaint rate, multiple linear regression was performed on 4051 sets of data for all the hotels. In order to unify the units between the variables, first, the extreme value method was used to make dimensionless all the data according to Equation (2), and then a new set of data was obtained:

$$x_i' = [x_i - \min(x_1, \ldots, x_i)]/[\max(x_1, \ldots, x_i) - \min(x_1, \ldots, x_i)] \ (i = 1, 2, 3, \ldots, 4051) \quad (2)$$

The standardized hotel total score is the explained variable, denoted by y. The explanatory variables include the total complaint rate x_1, the acoustic environment complaint rate x_2, the luminous environment complaint rate x_3, the IAQ complaint rate x_4 and the thermal environment complaint rate x_5. Then, the unary linear regression model was established as shown in Equation (3):

$$y_i = \beta_0 + \beta_1 * x_{1,i} + \varepsilon_i \ (i = 1, 2, 3, \ldots, 4051) \quad (3)$$

Stata16.0 was used to perform linear regression on y and x_1. The regression results are shown in Table 5 and passed the significance test at the 1% level. That means the total complaint rate had a significant negative impact on the total score; that is, IEQ complaints will reduce customer satisfaction.

Table 5. The regression results for the total score and total complaint rate.

y	Coef.	Std. Err	t	$p > |t|$
x1	−0.635	0.266	−23.830	0.000

In order to further explore the impact of the complaint rates of different IEQ types on customer satisfaction, a multiple regression model, as shown in Equation (4), was established to perform regression analysis on y and x_2, x_3, x_4 and x_5. At the same time, in order to solve the problem of multicollinearity among the variables, after regression, the variance inflation factor (VIF) was calculated to test whether there was multicollinearity between the variables:

$$y_i = \beta_0 + \beta_1 * x_{2,i} + \beta_2 * x_{3,i} + \beta_3 * x_{4,i} + \beta_4 * x_{5,i} + \varepsilon_i \ (i = 1, 2, 3, \ldots, 4051) \quad (4)$$

The regression results are shown in Table 6. The *p* values of the t-test were 0, and all passed the significance test at the 1% level. It can be seen from the results of the collinearity

test that the VIFs of all variables were less than three, indicating that there was no serious collinearity between the variables.

Table 6. The regression results for the total score and complaint rates of the acoustic environment, luminous environment, IAQ and thermal environment.

	Coef.	Std. Err	t	$p > |t|$	Vif
X2	−0.291	−0.030	−9.570	0.000	1.030
X3	−0.291	−0.0256	−11.370	0.000	1.030
X4	−0.655	−0.037	−17.560	0.000	1.070
X5	−0.453	−0.042	−10.680	0.000	1.030

It can be seen from the regression results in Table 6 that the regression coefficients of all variables were negative, which shows that acoustic environment complaints, luminous environment complaints, IAQ complaints and thermal environment complaints all had a significant negative impact on customer satisfaction. However, different types of IEQ complaints made different "contributions" to the score reduction. IAQ had the greatest impact on the hotel's total score. That is, compared with the other three types of IEQ problems, when air quality problems occurred, customers would give lower scores. This may be related to the increasing public attention to air quality problems in recent years. In addition, related studies have shown that poor IAQ will significantly affect the sleep quality and comfort of building occupants [47]. IAQ is very important in relation to mood changes. Discomfort caused by severe air pollution can cause people to feel anxious and irritable [48], which may also be an important factor in customers giving low scores with IAQ problems.

The thermal environment had an impact on the hotel's total score, second only to air quality. This may be due to more triggers for thermal environment problems. The thermal environment is easily affected by factors such as the temperature, humidity and air velocity. More triggers mean more complaints from customers. Compared with IAQ and the thermal environment, the acoustic environment and luminous environment had relatively small impacts on customer satisfaction.

Combining Table 6 and the complaint rates of each IEQ discussed in Section 4.1.2, the score was not strictly inversely proportional to the complaint rate, which is not consistent with the general public perception. For example, the complaint rate of the acoustic environment was the highest, but from the coefficient of multiple linear regression, the impact of the acoustic environment complaint on the score was the lowest. This shows that customers have a relatively high tolerance for noise, which may be related to the prevalence of noise problems. Their universality improves customers' adaptability to noise. Although the complaint rate was relatively high, customers did not give a low score. In comparison, the complaint rate of the IAQ was less than half of that of the acoustic environment. However, IAQ complaints had the greatest impact on hotel scores, which shows that customers have a low tolerance for IAQ. This result also provides the best solution for managers of budget hotels to improve customer satisfaction. For example, managers can improve the hotel's ventilation or air purification equipment and, by meeting customers' IAQ needs, the hotel's online score can be greatly improved, thereby attracting more customers.

4.4. Source Analysis of IEQ Complaints

This paper not only studies the IEQ complaint rate, but also discusses the main causes of complaints, which will be more helpful for improving the IEQ of China's budget hotels. Mainly based on text mining with manual screening as a supplement, keyword extraction of each review containing IEQ problems was carried out, and the causes of complaints were classified. Considering that there are many causes of customer complaints against IEQ, it was impossible to list them all. The causes that accounted for relatively large proportions were focused. When the sum of the ratios of the main causes reached 80%, the remaining causes were classified as "other".

4.4.1. Source Analysis of Acoustic Environmental Complaints

Generally speaking, the noise in a hotel mainly include indoor noise and outdoor noise. These noises are usually generated by natural (waves or wind turbulence) as well as human (industrial facilities, household appliances or transportation) sources [66]. Traffic noise and noise generated by neighbors are typical causes of poor acoustic environments [54].

Figure 10a shows the causes of acoustic environment complaints in the budget hotels analyzed in this paper. Among all the acoustic environment complaints, 21.48% of customers only complained about the "poor sound insulation" of the hotel building but did not specify a clear cause of the noise. Among the acoustic environment complaints with clear causes, the main cause was noise generated by surrounding customers, accounting for 20.52% of the acoustic environment complaints. For example, customers reported that "the sound of chatting and watching TV next door in the middle of the night was too noisy to sleep" and "the sound of the next-door guest singing in the middle of the night was noisy". The second main cause of acoustic environment complaints was outdoor noise, excluding traffic noise, which accounted for 17.52% of the complaints. For example, customers reported that "the surrounding environment was very noisy and I was woken up by a radio broadcast outside in the morning", "there seems to be a KTV next to it, which was very noisy" and so on. Noise from air conditioning was the third main cause of acoustic environment complaints, accounting for 12.74% of the complaints. For example, customers reported that "air conditioning blades vibrate loudly" and "the equipment was old, mainly air conditioners, and the noise was loud". Traffic noise was the fourth main cause of acoustic environment complaints, accounting for 10.27% of the complaints. For example, many customers complained that "the room is near the elevated highway and the noise is a bit loud at night", "the main road downstairs, the whistle of cars, and the sound of motorcycles were very, very noisy" and so on. In addition, 17.47% of the causes of acoustic environment complaints were classified as "other", mainly including construction noise, equipment noise and complaining about noise but not mentioning the cause.
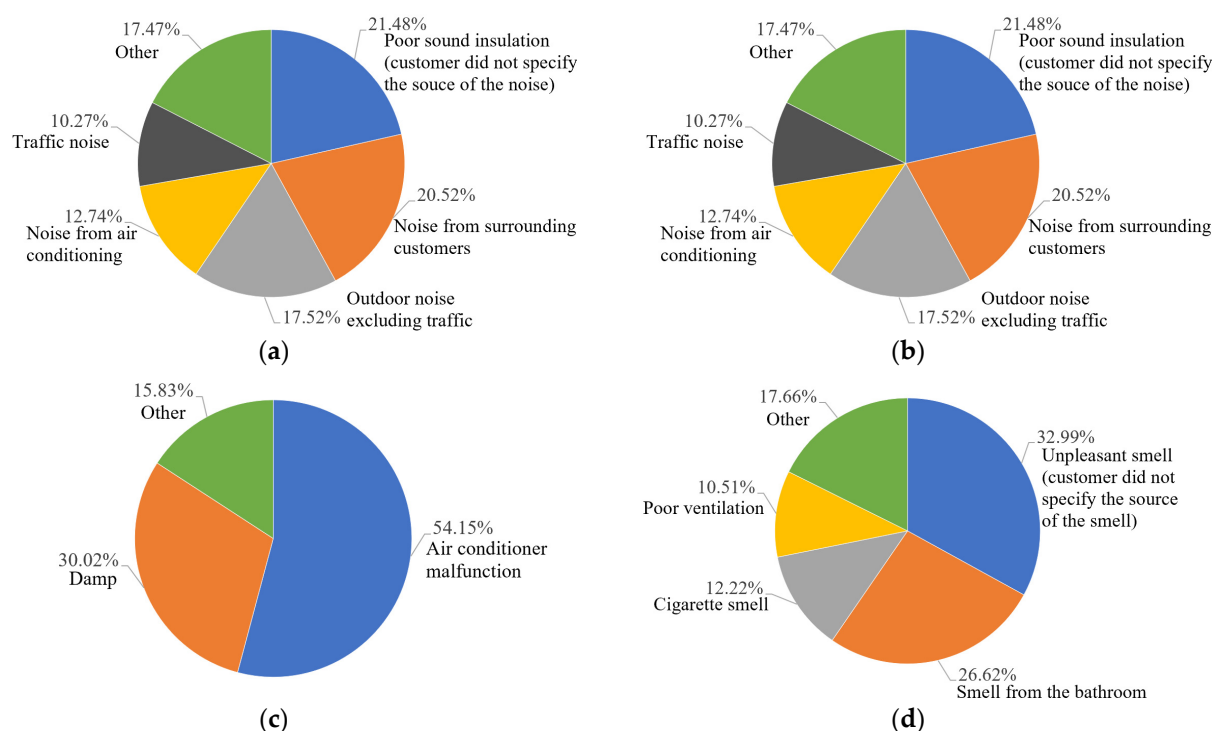

Figure 10. Analysis of sources of complaints in different categories of IEQ. (**a**) Acoustic environment; (**b**) IAQ; (**c**) Thermal environment; (**d**) Luminous environment.

Noise is closely related to architectural design. The level of noise is mainly related to the absorption characteristics of a room's surfaces and the volume of the space [67]. Considering that the acoustic quality of a building is an effective way to improve the comfort of the building, the design of hotel buildings can be aimed at the main concerns of customer complaints, improving the acoustic quality to meet the requirements of residents. For example, sound-absorbing materials can be used in rooms to achieve a certain degree of noise control in order to prevent customers from feeling discomfort due to noise.

4.4.2. Source Analysis of IAQ Complaints

The IAQ in a building is affected by many factors, such as outdoor conditions (climate), building conditions (materials, structure and construction) and the building's HVAC (heating, ventilation and air conditioning) system. These factors are often interdependent and dynamically affected by multiple changes and interactions [68,69].

Figure 10b shows the causes of IAQ complaints in the budget hotels. Among these, 32.99% of customers only complained about a peculiar smell in the indoor air without specifying clear causes. In complaints indicating the cause of IAQ, the main cause was the smell of the toilet, accounting for 26.62% of the complaints. For example, customers reported that "the toilet smells very big" and "the toilet drain smells bad". The second source of IAQ complaints was a cigarette smell, accounting for 12.22% of the complaints. For example, customers complained that "the room has a heavy smell of cigarettes" and "the smell of smoke is smelled as soon as you enter the door". In addition to peculiar smells, poor ventilation, accounting for 10.51% of the complaints, was also a main cause of IAQ complaints. For example, customers complained that "the room is basically not ventilated and very stuffy" and "the ventilation is poor and there is no exhaust fan". In addition, some causes accounted for relatively small proportions, so they were classified as "other", accounting for 17.66% of the complaints, such as paint smells, formaldehyde smells, disinfectant smells, musty smells, decoration smells and so on.

Generally speaking, by increasing the ventilation rate to exchange indoor air and remove carbon dioxide and other pollutants in the air, the IAQ can be effectively improved [70]. Moreover, higher ventilation rates in buildings can also save energy and maintenance costs, thereby increasing financial returns. Therefore, for budget hotels, efforts should be made to improve the ventilation rate, such as increasing the settings of windows and installing ventilation equipment.

4.4.3. Source Analysis of Thermal Environment Complaints

The thermal environment is mainly affected by the radiation temperature, air temperature, air velocity and relative humidity. The judgment of thermal comfort is a cognitive process which is affected by physical, physiological and psychological factors and may vary from person to person.

Figure 10c shows the causes of thermal environment complaints in budget hotels in China. Air conditioning malfunctions were the main cause of thermal environment complaints, accounting for 54.15% of the complaints. Customers mainly complained about the heating or cooling effects of the air conditioning, such as "air conditioning cooling effect is not good" and "air conditioning not heating". Dampness was the second major cause of thermal environment complaints, accounting for 30.02% of the complaints. For example, customers complained that "the room is relatively humid", "the bedding and mattress are wet" and so on. In addition, air dryness, heating problems and complaints about cold or heat that did not specify the cause were classified as "other", accounting for 15.83% of the complaints.

At present, adjusting the indoor temperature through the air conditioning system to provide a satisfactory thermal environment for occupants is the main solution to the problem of thermal discomfort. The advancement of air conditioning technology also provides greater possibilities for improving the thermal environment. In particular, many current air conditioners have dehumidification functions, which can not only solve the

problems of cold and heat, but also solve the problems of moisture and dryness. Therefore, hotel managers can greatly improve the thermal environment of their hotel through the rational use of air conditioners.

4.4.4. Source Analysis of Luminous Environment Complaints

The causes of luminous environment complaints were mainly related to the lighting level. Studies have shown that exposure to insufficient or inappropriate light can disrupt the standard rhythm of humans, which will adversely affect performance, safety and health [71].

Figure 10d shows the causes of luminous environment complaints. Lamp problems, including damage to lamps, dim enough lamps and too few lamps, were the main cause of luminous environment complaints, accounting for 78.77% of the complaints. For example, customers reported that "two lamps are broken, not repaired, and dim at night", "the lighting is relatively dim" and "there are too few lights and the room is not bright". Natural lighting was the second main cause of luminous environment complaints, accounting for 14.95% of the complaints. For example, customers complained that the "room windows are very small and natural lighting is poor" and "the room has no windows and no sunlight can be seen". In addition, causes including poor shading, glare from the sun and glare from lights were classified as "other", which accounted for 6.28% of the complaints.

Although the complaint rate of the luminous environment was not high, the importance of the luminous environment cannot be ignored. A good luminous environment helps to create a pleasant atmosphere in a room, thereby improving customers' perception of the IEQ. Therefore, this factor should be considered when designing a hotel so that the characteristics of the luminous environment correspond to the needs and expectations of users, thereby helping customers maintain a relaxed state, which in turn improves their overall satisfaction with the hotel's IEQ.

5. Conclusions

Improving the IEQ of hotels is essential to promote the sustainable development of the hospitality industry. Post-occupancy evaluation (POE) is the traditional method for investigating the IEQ in hotel buildings, but this method has the disadvantages of a small sample size and being time-consuming and laborious. The development of online booking platforms has provided a new source of data for the IEQ assessment of hotels, and with the help of text mining methods, IEQ factors in online reviews can be extracted automatically and easily. Based on this, this study collected data in the form of 2.06 million online reviews of budget hotels from the largest hotel online booking platform in China through a web crawler method, extracted the IEQ factors contained in these online reviews using text mining methods and analyzed the variability of IEQ complaints under different conditions and the main causes of said complaints.

The results show that budget hotels in China have more serious IEQ problems. Their complaint rate is about three times higher than the complaint rate of five-star hotels measured by existing studies. Of all IEQ problems, acoustic environmental problems occurred most frequently. In addition, the season and climatic region have a significant impact on the IEQ. For example, the IAQ complaint rate decreases significantly in the winter, and the thermal environment complaint rate is significantly higher in severe cold regions than in other regions. There are significant differences in the perception and evaluation of IEQ by different types of customers, with solo travelers and couples being more sensitive to IEQ. IEQ complaints significantly reduce customer satisfaction; however, the IEQ complaint rate is not strictly inversely related to customer satisfaction. For example, the complaint rate of the acoustic environment was the highest, but the impact of the acoustic environment complaint on customer satisfaction was the lowest. Analysis of the sources of IEQ complaints shows that the causes of complaints about the IEQ were relatively concentrated, and that hotel managers could significantly reduce the rate of IEQ

complaints by focusing on improving the few IEQ issues that led to a high number of customer complaints.

This study has both theoretical and practical implications. Theoretically, the study provides a research reference for the comprehensive analysis and exploration of the influencing factors of the indoor environment. While most previous studies have only analyzed one of the aspects of the acoustic environment, luminous environment, IAQ and thermal environment, this study combines online reviews to comprehensively assess the IEQ of budget hotels in China from the above four aspects and analyses the differences in IEQ complaints in different seasons and regions, as well as the differences in the perception of the IEQ by different customer types. On the other hand, the study extends the research on hotel IEQ to budget hotels, further enriching the research related to hotel IEQ and making up for the shortcomings of previous studies, which only focused on five-star hotels. Practically, this study can provide a reference for hotels, especially budget hotels, on how to improve the IEQ, which has certain practical significance for improving the service quality and promoting the sustainable development of the hospitality industry.

The research reported in this paper also has certain shortcomings. For example, accurately identifying IEQ-related keywords in Chinese reviews still faces difficulties. The Chinese corpus is relatively rich, having the same meanings but many expressions. The true meanings of these terms cannot be recognized through automatic extraction, which will affect the accuracy of the analysis. In addition, factors other than the IEQ that affect customer satisfaction with budget hotels need to be studied in depth, such as small spaces, poor sanitation, outdated facilities and inadequate services, all of which will adversely affect customers' experiences. This awaits further research in the future.

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