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Indoor Air Quality Certification and Consumers' Willingness: Taiwan's Experience and Survey

Chih-Pei Hu [1,*] and Jen-Hsiung Cheng [2]

[1] Department of Public Administration, Chung Hua University, Hsinchu 30012, Taiwan
[2] Taiwan Indoor Environment Quality Management Association, New Taipei City 23555, Taiwan; ieqm.tw@msa.hinet.net
* Correspondence: billhu0711@gmail.com

Abstract: People spend about 80–90% of their time in indoor environments, and poor indoor air quality (IAQ) can seriously endanger people's health, work quality, and efficiency. The Taiwan Government began regulating IAQ in 2011 and implemented the self-managed IAQ certification in 2021. Before the Taiwan Government officially implemented the certification, we conducted a questionnaire survey from 26 to 27 September 2020. Moreover, this survey selected Banqiao and Wuri High-Speed Rail Plaza as the survey sites and completed 337 valid questionnaires. According to the hierarchical regression results, this research found the following: firstly, IAQ certification complies with international standards and has continuous monitoring and information disclosure methods, both of which are key factors affecting people's willingness to consume; secondly, the respondents, who are female, familiar with the regulations, and living in the northern Taiwan area, have more willingness to consume in the certificated places.

Keywords: indoor air quality; IAQ citification; consumers' willingness; Taiwan's experience

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1. Introduction

According to the Environmental Protection Administration of the R.O.C. (TW EPA), each person spends about 80–90% of the time in an indoor environment (including homes, offices, or other buildings) [1]. Therefore, when the indoor air quality (IAQ) is poor, it can seriously endanger people's health, work quality, and efficiency. In particular, if indoor ventilation is insufficient in a closed building for a long time, pollutants are likely to accumulate and deteriorate the IAQ. Sometimes, people within closed buildings experience acute uncomfortable symptoms caused by unknown reasons that often disappear after leaving. This is known as the so-called "sick-building syndrome" condition (sick-building syndrome—SBS). If people stay in such buildings over long periods of time, in which the IAQ is poor or the indoor air is polluted, this will easily lead to abnormal human symptoms such as neurotoxic symptoms (including eye, nose, and throat irritation), a pungent or unpleasant smell, and induced asthma attacks. Indeed, the IAQ impacts human health, especially during the COVID-19 outbreak, in which people have significantly increased their indoor time. To prevent the spread of COVID-19, many people may not open doors and windows to allow in the fresh air, resulting in poor ventilation and deterioration of IAQ.

1.1. Indoor Air Quality

1.1.1. Definition and Its Effects

The IAQ is particularly important since people stay indoors for a long time. Steinemann et al. [2] pointed out that IAQ definitions can vary depending on the perspectives of the user, as well as the indoor air of the space and the source of indoor air pollution. In fact, indoor air quality is affected by outdoor sources and building design, especially regarding ventilation and physical parameters (relative humidity and temperature) [3]. The

World Health Organization (WHO) [4] defined healthy IAQ as "no harmful concentrations of pollutants are found in the air, and at least 80% of users are not dissatisfied with air quality." The US Environmental Protection Agency [5] also defined IAQ as the air quality inside and around buildings and structures, especially because it is related to the health and comfort of the occupants of the building. Understanding and controlling common indoor pollutants can help reduce risks related to indoor health problems.

In 1988, the WHO held the first meeting on the IAQ and health and generated a vast amount of reliable information on the impact of degraded IAQ on workers' health and productivity. Past research on IAQ usually focused on ventilation, health hazards, and creating a comfortable environment. In general, the scientific literature shows that good or improved indoor air quality increases productivity in the workplace and reduces absenteeism, which provides substantial financial benefits, which usually greatly exceeds the associated costs [6]. In other words, improving IAQ can not only protect the health and well-being of building occupants but also generate considerable financial returns on investment.

1.1.2. Organizations and Improvements

The IAQ is not only related to health outcomes, indoor air pollutant exposure, and occupants' satisfaction with the environment but also to overall human well-being, cognitive performance, and learning [7]. Therefore, organizations and governments, within their technical documents and position papers, have always emphasized the determinants of IAQ on human health and the potential existence of harmful pollutants released from indoor sources [8].

The first study on comfort and IAQ conditions was in the 19th century, which measured fresh air. With the energy crisis in the second half of the 19th century, research on IAQ increased rapidly [9]. Many organizations and governments are currently working to improve information about indoor air quality, setting priorities and goals, and providing various legal research, monitors, setting standards, and environmental protection for indoor air quality. Table 1 highlights IAQ-related work in some countries and organizations.

Table 1. Countries and organizations working on IAQ.

Country	Organization	Country	Organization
Worldwide	WHO	China	AQSIQ, SEPA
Worldwide	ISO	Malaysia	DOSH
Worldwide	International Society of Indoor Air Quality and Climate	Japan	MHLW
Worldwide	AIVC	Korea	KEITI
USA	ASHRAE, OSHA, US EPA	Taiwan (R.O.C.)	TW EPA
UK	HSC REHVA	Germany	MAK
EU	The Joint Research Center CEN, the European Committee for Standardization	Canada	Health Canada

According to research, poor IAQ has an important impact on human health, performance, and productivity and should be regarded as a public health issue. Therefore, indoor environmental conditions improved through enhanced ventilation strategies should be opportunities for people's health, performance, and productivity [10]. Hawkins et al. [6] argued that improvements in the IAQ have also been found to reduce employee absenteeism, reduce reported work stress, and increase job satisfaction. Some specific IAQ improvements related to these benefits include increased ventilation; reduced emissions of chemicals and other pollutants; improved air filtration, temperature and humidity control; and reduced moisture and mold in buildings. In other words, building design, construction, renovation, and ongoing maintenance can enable the identification and resolution of potential and actual IAQ issues.

1.2. Taiwan's Experience

1.2.1. Legislation and Regulated Places

Since 1998, the TW EPA has conducted surveys and research on the indoor and IAQ of relevant occupational sites. Accordingly, the Taiwan Government passed the "Indoor Air Quality Management Promotion Plan" drafted by the TW EPA in 2005 and then announced the "Recommended Indoor Air Quality Values" at the end of 2005 to provide users with a reference for management [11]. After years of research and policy formulation, the Taiwan Government passed the "Indoor Air Quality Act" on 8 November in 2011 and became the second country (after South Korea) to compulsorily incorporate indoor air quality management into legislation and extended air quality management from outdoor to indoor. Today, Taiwan's Indoor Air Quality Act has been formally implemented for 10 years and has a total of 10 relevant regulations, orders, and directions (see Table 2). The Indoor Air Quality Information Network. Available online: https://iaq.epa.gov.tw/indoorair/introduction_importance.aspx (accessed on 1 September 2021).

Table 2. IAQ regulations in Taiwan.

Rank	Title	Announced Date
Act	Indoor Air Quality Act	23 November 2011
Order	Indoor Air Quality Act Enforcement Rules	23 November 2012
Order	Indoor Air Quality Standards	23 November 2012
Order	The Regulations of Establish Specialized Personnel for Indoor Air Quality Maintenance and Management	11 August 2016
Order	The Regulations of the Indoor Air Quality Inspection and Determination in Specific places	23 November 2012 9 August 2021 (amended)
Order	The Regulations of the Violate Indoor Air Quality Act Penalty Limits and Guidelines	23 November 2012
Order	The First Batch of Specific Places Comply with the Indoor Air Quality Act	23 January 2014
Order	The Second Batch of Specific Places Comply with the Indoor Air Quality Act	11 January 2017
Direction	Operation Directions for Self-Management Marks of Indoor Air Quality by Environmental Protection Administration of the Executive Yuan	2 July 2021
Other	Indoor Air Quality Maintenance and Management Plan Document	June 2016 (amended)

In 2014, the TW EPA made an announcement: "The First Batch of Specific Places Comply with the Indoor Air Quality Act"; therefore, the objects of this study are people gathering, entering, and exiting specific public and private places or the risk of indoor air pollutants and the special needs of these places. The First Batch of Specific Places includes colleges, libraries, medical institutions, social welfare institutions, government offices, railway transportation stations, civil aviation stations, mass rapid transit systems, transportation stations, exhibition rooms, conference halls, shopping malls, and another ten types.

Moreover, "The Second Batch of Specific Places Comply with the Indoor Air Quality Act" was also announced in 2017. Under this order, owners, managers, and users of specific places were also required to complete management plans, inspections, and records every year. This announcement included an additional six types of places, including museums and art galleries, financial institutions, performance halls, cinemas, KTVs, and sports centers, with a total of 940 places under regulation.

To date, there has been no clear time schedule for the third batch of specific places that could be announced. In addition, small public places, such as kindergartens, gyms, and long-term care centers, that were selected in this research may be included in the next regulation. In other words, Taiwan's implementation of the IAQ management continuously expands the policy coverage within 10 years.

1.2.2. Standards, Inspections, and Certifications

The concentration of indoor air pollutants is closely related to the activities of indoor personnel and the use of equipment. According to the IAQ standards announced by the Taiwan Government, controlled pollutants include carbon dioxide (CO_2), carbon monoxide (CO), formaldehyde (HCHO), total volatile organic compounds (TVOC), bacteria (bacteria), fungi (fungi) (the indoor and outdoor concentration ratio is less than or equal to 1.3, which is no longer limited), 10 microns suspended particles (PM_{10}), 2.5 microns suspended

particles ($PM_{2.5}$), and ozone (O_3). At the same time, the standard clearly stipulates the relevant pollutant audit and prohibition penalty standards (see Table 3).

Table 3. Standard values of indoor air pollutants in Taiwan.

Item	Standard Values		Unit
CO_2	8 h	1000	ppm
CO	8 h	9	ppm
HCHO	1 h	0.08	ppm
TVOC	1 h	0.56	ppm
Bacteria	Highest value	1500	CFU/m^3
Fungi	Highest value	1000	CFU/m^3
PM_{10}	24 h	75	$\mu g/m^3$
$PM_{2.5}$	24 h	35	$\mu g/m^3$
O_3	8 h	0.06	ppm

At the same time, IAQ inspection and determination are divided into two categories:

1. Regular inspection: specific places that are under-regulated should conduct indoor air pollutant concentration measurements within a prescribed period and regularly announce the inspection and measurement results.
2. Continuous monitoring: government-designated specific places must set up automatic monitoring facilities. The owner, manager, or user who approved the automatic monitoring facilities should continue to measure indoor air pollutant concentrations and display the latest measured values in real time.

In 2021, the Taiwan Government's management of IAQ made another leap forward. To advocate self-maintenance of the IAQ in public and private places, the Taiwan Government announced the self-management certification of IAQ. If the IAQ of public and private spaces is deemed to meet the standard of the certification mark after review, then those sites will be awarded a certification. The self-management certification is applicable to 19 categories—colleges and universities, libraries, museums and art galleries, medical institutions, social welfare institutions, government offices, railway stations, airports, mass rapid transit system stations, financial institutions, performance halls, exhibition rooms, cinemas, KTV, shopping malls, gyms, kindergartens, post-natal care institutions, and baby care centers. Specific places, regardless of whether or not they have been previously regulated, are divided into two levels (see Figure 1):

1. Excellent: the certification is valid for three years, within self-inspections every six months and regular inspections completed once every three years.
2. Good: the certification is valid for two years, with self-inspections before regular inspection and regular inspection completed once every two years.

Once a private or public place has applied for the mark, the certification is placed on the service counter or at an obvious location at the entrance for public identification. According to current regulations, different types of places have designated certified IAQ standards (see Table 4). Only the selected three categories of places—related to this research—are shown here.

In the past, IAQ research focused on instrument measurement and controlling air pollutants; however, recent public awareness of IAQ also gained traction. Firstly, IAQ surveys in Taiwan are generally based on presenting technical monitoring data—the subjects are mostly medical institutions. At the same time, the surveys can be roughly divided into three types: measurement quality and comparative analysis [12,13], measurement as the main part and supplemented by some subjective questionnaire surveys [14], and pure public IAQ perception surveys [15,16]. Secondly, IAQ surveys around the world have also

shown different characteristics in recent years: combining instrumental measurements and subjective questionnaires [17–21] and IAQ perception surveys for specific spaces [22,23]. It is worth mentioning that some research has emphasized public IAQ perception surveys and conducted comparative analyses [24].

Figure 1. IAQ certification mark in Taiwan.

Table 4. Selected cases of the IAQ certification standard in Taiwan.

Place	Indoor Air Pollutant Items	Monitoring Period	Excellent Level Standard (Unit)	Good Level Standard (Unit)
Gym/kindergarten	CO_2	8 h	800 (ppm)	1000 (ppm)
	HCHO	1 h	0.03 (ppm)	0.08 (m)
	Bacteria	Highest value	800 (CFU/m^3)	1500 (CFU/m^3)
	PM_{10}	24 h	50 (μg/m^3)	75 (μg/m^3)
Long-term care center * (social welfare institutions)	CO_2	8 h	800 (ppm)	1000 (ppm)
	CO	8 h	2 (ppm)	9 (ppm)
	HCHO	1 h	0.03 (ppm)	0.08 (ppm)
	Bacteria	Highest value	800 (CFU/m^3)	1500 (CFU/m^3)
	PM_{10}	24 h	50 (μg/m^3)	75 (μg/m^3)

* Long-term care centers refer to use social welfare institution standards.

According to the above analysis, the differences between this research and others are: First, this is a first-hand survey and pilot study before the Taiwan Government officially implemented the self-management IAQ certification; second, the questionnaire contains not only traditional basic information, symptoms, and cognition of IAQ but also the opinions and evaluations of the IAQ certification system; finally, this research extended the subject—of IAQ's survey—to the consumer behavior field and conducted a regional comparative analysis. Therefore, this is a subject that has rarely appeared in related research yet is an innovative and practical topic.

Related studies have pointed out that having excellent IAQ can promote human health and increase productivity; however, there is little discussion regarding whether these environmental conditions can cause people to go or even have the willingness to consume. Accordingly, this research aims to use empirical investigations to understand whether government-certified IAQ places can promote people's willingness to consume and related relevant influencing factors.

As mentioned above, this research mainly aims to understand the public's views on the self-management certification system promoted by the Taiwan Government and whether it will affect their willingness to consume. This research proposes the hypothesis

that the public's cognition of IAQ certification and displaying certification information are both key factors that affect people's willingness to consume.

2. Materials and Methods

2.1. Research Design and Methods

The IAQ standards and specifications are discussed in many related studies, but the impact on consumption willingness is seldom discussed. To understand the relationship between IAQ certification and consumption willingness, this research specifically designed a questionnaire using the public's cognition of IAQ certification and certification information as an independent variable and the consumption willingness of certified locations as a dependent variable. Therefore, this research proposes the following hypotheses:

Hypothesis 1 (H1). *The cognition of IAQ certification will affect their willingness to consume.*

Hypothesis 2 (H2). *The display method of IAQ certification information will affect their willingness to consume.*

Hypothesis 3 (H3). *Both the cognition of IAQ certification and the way of displaying information will strengthen their willingness to consume.*

To ensure survey respondents have a certain degree of regional representativeness, this research specifically selected areas with dense populations, high economic development, and urbanization in Taiwan. Therefore, the high-speed rail station plaza, with a large crowd and an important transportation hub, was selected as the survey site. For the feasibility and convenience of the investigation, this research cooperated with the Taiwan Indoor Environment Quality Management Association—TIEQMA is one of the few non-governmental professional organizations in Taiwan that focuses on IAQ-related issues. It also gathers experts in various fields such as environmental protection, air conditioning, construction, and improving technology to promote the indoor air quality industry to formulate unified standards, technical guidance, education and training, and assistance in the promotion of related laws and regulations. Official Website: https://www.tieqm.com/, accessed on 1 September 2021 (TIEQMA)'s annual activities to conduct two-day investigations at Banqiao and Wuri High-speed Railway Station Plaza.

The survey is combined with TIEQMA's annual public welfare activities. The association regularly promotes IAQ-related information and improvement methods every year. At the same time, on the two days of the survey, the association mobilized many volunteers, university professors, and students to randomly invite people concerned about IAQ issues to fill out the questionnaire. Each respondent is fully informed of the purpose of the questionnaire and how the relevant information will be used.

Therefore, the survey subjects of this research can be divided into two groups: one is the people living cycle around the Banqiao High-Speed Station (north area of Taiwan), and the other is around the Wuri High-Speed Station (middle area of Taiwan). For the questionnaire (see Appendix A), we consulted and communicated with the TIEQMA several times during the design process, and so it has a certain degree of expert validity. The questionnaire was also pre-tested before being formally conducted and was revised according to the results.

The questionnaire used in this research can be divided into five parts: (1) basic information of the respondents, including four variables, i.e., gender, age, marriage, and education; (2) practical experience and knowledge of the IAQ scale section, in which there are also six questions; (3) certification cognition scale section, including four questions (Cronbach's Alpha = 0.760); (4) certification displays scale section—there are only three questions that require responses (Cronbach's Alpha = 0.872); and (5) willingness to consume at certified places scale section, in which there are four questions that require answering by respondents (Cronbach's Alpha = 0.772).

2.2. Data and Survey Sites Selection

The survey was conducted between 09:00 and 17:00 from 26 September (Banqiao) to 27 (Wuri) in 2020—at that time, the COVID-19 pandemic in Taiwan had not broken out seriously, and the main pandemic prevention measures in place during this period were mask wearing and maintaining social distancing—and as mentioned above, it mainly included two types of respondents. In addition, Banqiao Station, which is close to the north area of Taiwan including Taipei City and New Taipei City, both have a population of approximately 6.9 million (30% of Taiwanese residents); Taipei City is Taiwan's economic and financial center, and many domestic and foreign corporate headquarters and financial institutions; New Taipei City is the most populous city in Taiwan and is dominated by manufacturing and construction industries; the Wuri Station near to the middle area of Taiwan includes three counties, with a population of approximately 4.7 million (25% of Taiwanese residents), and it is the second-largest metropolitan area in Taiwan, mainly in manufacturing areas and agricultural and fishing villages. Therefore, northern Taiwan is the most densely populated area with the best economic development, while the middle area of Taiwan is an emerging metropolis. According to statistics from the Taiwanese Government in 2020, the monthly consumption expenditure of residents of northern Taiwan is about USD 1100, while that of central Taiwan is close to USD 850.

High-speed rail is currently one of Taiwan's most important modes of transportation, connecting many important cities and driving regional population growth and economic development. The main reasons why Banqiao and Wuri Station were selected as the survey bases in this research are: First, Banqiao Station is a three-rail joint construction (high-speed rail, railway, and MRT), connecting the largest metropolitan area in northern Taiwan; second, Wuri Station is a transportation hub in the adjacent area, with expressways and railways connecting Taiwan's second-largest central metropolitan area; finally, both sites are crowded and traffic-heavy and are important transportation locations for Taiwan's important population clusters and high urbanization areas.

This research is limited by funding, so convenience sampling is mainly adopted, and the results cannot be inferred to other groups. There were 337 copies of valid questionnaires, including 189 copies from Banqiao and 148 copies from Wuri.

3. Results

3.1. Descriptive Analysis of the Results

This survey applied the hierarchical regression analysis, using the certification cognition and display as the independent variable, the willingness to consume at certified places as the dependent variable, and testing whether there were significant differences among the three scales (background information, experience, and knowledge of the respondents as the control variable).

3.1.1. Features of Samples

According to the basic information of the 337 respondents, the main components were as follows: 56.1% of respondents live around the north of Taiwan, 68.8% of the sample were females, 22.3% respondents were aged 41–50 and 51–60 years old, 57.3% of the respondents are married, and 42.4% hold a college or university education degree. Furthermore, the Banqiao and Wuri samples collected in this research have the following characteristics (see Table 5):

Firstly, most of the respondents at Banqiao Station are female, older, with higher education, and have relatively no air allergy symptoms.

Secondly, the samples at Wuri Station are also mostly female, younger, have college degrees, and more are acknowledgeable of relevant laws and regulations.

These results are not completely consistent with the real demographic characteristics of Taiwan. The main reason for this bias is that the survey was conducted on weekends, and the convenience sampling design was adopted.

Table 5. Comparison of Banqiao and Wuri sample features.

Survey Site		Banqiao (*N* = 189)		Wuri (*N* = 148)	
Items		**Frequency**	**Percentage**	**Frequency**	**Percentage**
Gender	Female	133	70.4%	99	66.9%
	Male	56	29.6%	49	33.1%
Age	Under 20	7	3.7%	14	9.5%
	21–30	21	11.1%	36	24.3%
	31–40	37	19.6%	20	13.5%
	41–50	41	21.7%	34	23.0%
	51–60	41	21.7%	34	23.0%
	Above 61	42	22.2%	10	6.8%
Marriage	Married	120	63.5%	73	49.3%
	Unmarried	69	36.5%	75	50.7%
Education	Junior high school	17	9.0%	10	6.8%
	High school	29	15.3%	27	18.2%
	College	19	10.1%	13	8.8%
	University	71	37.6%	72	48.6%
	Master or PhD	53	28.0%	26	17.6%
Air allergy	Yes	82	43.4%	74	50.0%
	No	104	55.0%	74	50.0%
	Missing	3	1.6%	0	0%
Know the 1aw	Yes	83	43.9%	85	57.4%
	No	100	52.9%	52	35.1%
	Missing	6	3.2%	11	7.4%

In addition, on the practical experience and knowledge scale, this research designed questions related to understanding the real situation of the respondents. Firstly, 52.8% of the respondents have no symptoms of air allergy, and 49.9% of the respondents are aware of the government-enacted IAQ management laws. Secondly, the respondents are familiar with some indoor air quality pollutants and focus on specific items (see Table 6).

Table 6. The cognition of indoor air pollutants.

Item	*N*	Percentage	Item	*N*	Percentage
$PM_{2.5}$	230	68.9%	TVOC	149	44.6%
CO_2	213	63.8%	Bacteria	129	38.6%
HCHO	213	63.8%	O_3	127	38.0%
PM_{10}	183	54.8%	Fungi	75	22.5%
CO	177	53.0%	None	22	6.7%

Thirdly, most respondents are aware that the government has regulated some specific places; however, 24.9% of them express that they are unaware of any places (see Table 7).

Table 7. Top five responses of regulated specific places.

Places	*N*	Percentage
Medical institutions	186	55.7%
Mass rapid transit system stations	155	46.4%
Libraries	153	45.8%
Government offices	139	41.6%
Railway stations/airports	132	39.5%

3.1.2. Description of Scales

This research designed three scales to inquire about respondents' views and attitudes towards the IAQ certification, contents, and their willingness to consume in the certified

places. These scales used a five-point Likert scale (5 = strongly agree), and the mean and standard deviation (of the descriptive statistics) were used to analyze the results (see Table 8).

Table 8. The IAQ Certification cognition, displays, and the consumer's willingness.

Scale	Items	*N*	Mean	Standard Deviation
Certification cognition	Certification classification	335	4.4687	0.72472
	Comply with international standards *	334	4.4461	0.69431
Certification display	Monitoring equipment and bulletin board	327	4.3670	0.68723
	Replace paper poster	327	4.2813	0.76366
Consumer's willingness	Willing to pay a higher price	327	4.1468	0.87388
	Case1: Gym	327	4.3700	0.75986
	Case2: Kindergarten	327	4.5443	0.64377
	Case3: Long-term Care Center	326	4.5583	0.62362

* Since the respondents of the questionnaire in this study are public, not professionals, they are not familiar with various highly professional standards. Therefore, in the questionnaire design, the IAQ international standard description used in this research is used as an example of the IAQ standard in the WELL healthy building certification.

According to Table 8, the following findings can be summarized.

First, most of the respondents are willing to express their opinions, and their degree of agreement is very high (all means are above 4), especially some questions in the certification cognition and consumer's willingness scales.

Second, some responses in the scale are relatively consistent, e.g., the certified kindergartens (S.D. = 0.64377) and long-term care centers (S.D. = 0.62362) are willing to consume; some are relatively more divergent and appear in all three scales, such as the willingness to pay a higher price (S.D. = 0.87388), the certified gym (S.D. = 0.75986), replace the paper poster (S.D. = 0.76366), and certification classification (S.D. = 0.72472).

Overall, the responses in the survey are positive and affirmative—also expressed in the IAQ adopting certification, classification, and international standards items. In addition, if there are specific places that have been certified, their willingness to consume is also highly aggressive. Relatively speaking, regarding the certification display scale, respondents' opinions are minorly divergent.

3.2. Hierarchical Regression Analysis of Certification and Consume

For this section, this research used the respondents' seven-basic information as the control variable: gender (1 = man; 0 = female), age (1 = 15–39; 0 = above 40), marriage (1 = yes; 0 = no), education (1 = collage; 0 = high school), air allergy (1 = yes; 2 = no), know the law (1 = yes; 2 = no), and area (1 = Banqiao; 2 = Wuri). In addition, the certification cognition and display were used as the independent variable, the willingness to consume at certified places as the dependent variable, and the hierarchical regression analysis was employed to test for any significant differences in the scales.

3.2.1. Cognition Effect the Consumer's Willingness

In the certification cognition scale, this research designed two concepts: classification and compliance with the international standards. Therefore, we used these as the independent variable and tested whether there were significant differences in the consumer's willingness scales by regression analysis. According to the results in Table 9, the cognition of certification does affect the willingness to consume (all models $p < 0.001$); classification and compliance with international standards also show a low moderately positive correlation with consumer willingness and have certain predictions (all models Adj R^2 between 0.264 and 0.365). From the analysis results of the control variables, females are more willing to pay more for certified places, and people in northern Taiwan are also willing to send their children to certified kindergartens. This result may be because females may pay more

attention to environmental cleanliness; since northern Taiwan is a densely populated area with strict living conditions, people pay more attention to environmental quality.

Table 9. Certification cognition regression.

Independent Variables	Model 1 Pay High Price		Model 2 Gym		Model 3 Kindergarten		Model 4 Long-Term Care Center	
	B	**(S.E.)**	**B**	**(S.E.)**	**B**	**(S.E.)**	**B**	**(S.E.)**
Certification cognition	0.291 **	(0.105)	0.305 ***	(0.078)	0.264 ***	(0.067)	0.418 ***	(0.067)
Classification	0.368 ***	(0.098)	0.352 ***	(0.071)	0.345 ***	(0.062)	0.175 **	(0.062)
Comply with the international standards								
Control Variables								
Gender	−0.232 *	(0.101)	0.063	(0.075)	−0.006	(0.065)	0.059	(0.064)
Age	0.060	(0.114)	−0.014	(0.085)	0.011	(0.073)	0.010	(0.073)
Marriage	−0.221	(0.113)	−0.081	(0.084)	0.016	(0.072)	−0.042	(0.072)
Education	0.043	(0.111)	−0.149	(0.082)	−0.022	(0.070)	−0.062	(0.070)
Air allergy	−0.064	(0.096)	−0.069	(0.071)	−0.065	(0.061)	−0.060	(0.061)
Know the law	−0.088	(0.096)	−0.038	(0.071)	−0.018	(0.061)	−0.083	(0.061)
Area	0.030	(0.096)	−0.069	(0.071)	−0.135 *	(0.061)	−0.066	(0.061)
Constant	1.024 **	(0.358)	2.017 ***	(0.264)	1.867 ***	(0.226)	1.825 ***	(0.225)
Statistics	N = 265 F(9255) = 10.310 $p < 0.001$ $R^2 = 0.267$ Adj $R^2 = 0.244$		N = 265 F(9255) = 15.559 $p < 0.001$ $R^2 = 0.354$ Adj $R^2 = 0.332$		N = 265 F(9255) = 17.743 $p < 0.001$ $R^2 = 0.385$ Adj $R^2 = 0.363$		N = 265 F(9255) = 17.858 $p < 0.001$ $R^2 = 0.387$ Adj $R^2 = 0.365$	

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

3.2.2. Monitors and Bulletin Enforce the Attitude

In the certification display scale, this research also designed two concepts: monitors and information disclosure forms. Again, we used these to test the effects on consumers' willingness. According to the results in Table 10, the certification has a strong effect on the willingness to consume (all models $p < 0.001$); the monitors and bulletin have a moderately positive correlation with consumer willingness and have a prediction of around 40% (all models Adj R^2 between 0.381 and 0.396). Furthermore, we find that respondents who are familiar with the regulations pay a higher price in certified spaces, especially in the long-term care center. These people are aware of the relevant laws and regulations, and they also know that the certified places have better IAQ.

3.2.3. International Standards and Information Disclosure as the Key Factors

Finally, we combine the certification cognition and display scale and investigate the consumer's willingness results. From the previous analysis, a synergy result can be observed (see Table 11):

1. International standards and monitors still have a significant effect on consumer's willingness, in particular, the continuous monitors and bulletin is a key factor.
2. Further improvement in the degree of prediction, with an effect of close to 45% (all models Adj R^2 between 0.384 and 0.454).
3. Some features of the respondents still have a significant influence on different models, e.g., gender in high price, living area in kindergarten, and know the law in the long-term care center.

Table 10. Certification display regression.

Independent Variables	Model 1 Pay High Price		Model 2 Gym		Model 3 Kindergarten		Model 4 Long-Term Care Center	
	B	**(S.E.)**	**B**	**(S.E.)**	**B**	**(S.E.)**	**B**	**(S.E.)**
Certification display	0.667 ***	(0.087)	0.617 ***	(0.070)	0.475 ***	(0.061)	0.488 ***	(0.061)
Monitors and bulletin	0.157 *	(0.077)	0.022	(0.062)	0.095	(0.054)	0.092	(0.054)
Replace paper poster								
Control Variables								
Gender	−0.176	(0.092)	0.102	(0.075)	0.020	(0.065)	0.075	(0.064)
Age	−0.028	(0.104)	−0.073	(0.084)	−0.048	(0.073)	−0.024	(0.072)
Marriage	−0.115	(0.104)	−0.019	(0.084)	0.065	(0.073)	0.008	(0.072)
Education	0.122	(0.101)	−0.081	(0.082)	0.007	(0.071)	−0.020	(0.070)
Air allergy	−0.066	(0.087)	−0.079	(0.070)	−0.070	(0.061)	−0.051	(0.060)
Know the 1aw	−0.193 *	(0.087)	−0.121	(0.071)	−0.111	(0.061)	−0.166 **	(0.060)
Area	0.076	(0.088)	−0.059	(0.071)	−0.107	(0.061)	−0.048	(0.061)
Constant	1.114 *	(0.437)	2.038 ***	(0.354)	2.415 ***	(0.306)	2.032 ***	(0.210)
Statistics	N = 266 F(9256) = 18.478 $p < 0.001$ $R^2 = 0.394$ Adj $R^2 = 0.372$		N = 266 F(9256) = 18.036 $p < 0.001$ $R^2 = 0.388$ Adj $R^2 = 0.367$		N = 266 F(9256) = 17.488 $p < 0.001$ $R^2 = 0.381$ Adj $R^2 = 0.359$		N = 266 F(9256) = 18.641 $p < 0.001$ $R^2 = 0.396$ Adj $R^2 = 0.375$	

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

Table 11. Certification cognition and display regression.

Independent Variables	Model 1 Pay High Price		Model 2 Gym		Model 3 Kindergarten		Model 4 Long-Term Care Center	
	B	**(S.E.)**	**B**	**(S.E.)**	**B**	**(S.E.)**	**B**	**(S.E.)**
Certification cognition	0.036	(0.100)	0.143	(0.077)	0.110	(0.066)	0.277 ***	(0.066)
Classification	0.197 *	0(.091)	0.229 **	(0.070)	0.261 ***	(0.060)	0.086	(0.060)
Comply with the international standards								
Certification display	0.563 ***	(0.090)	0.422 ***	(0.073)	0.332 ***	(0.063)	0.334 ***	(0.062)
Monitors and bulletin	0.118 **	(0.079)	−0.017	(0.061)	0.067	(0.052)	0.032	(0.052)
Replace paper poster								
Control Variables								
Gender	−0.183 *	(0.092)	0.090	(0.070)	0.018	(0.060)	0.085	(0.060)
Age	−0.011	(0.103)	−0.061	(0.079)	−0.028	(0.068)	−0.030	(0.068)
Marriage	−0.119	(0.103)	−0.028	(0.079)	0.064	(0.068)	0.010	(0.067)
Education	0.131	(0.101)	−0.083	(0.077)	0.030	(0.067)	−0.010	(0.066)
Air allergy	−0.050	(0.086)	−0.055	(0.066)	−0.055	(0.057)	−0.050	(0.056)
Know the law	−0.155	(0.087)	−0.072	(0.067)	−0.049	(0.058)	−0.117 *	(0.057)
Area	0.074	(0.087)	−0.049	(0.067)	−0.116 *	(0.057)	−0.044	(0.057)
Constant	0.513	(0.476)	1.293 ***	(0.364)	1.601 ***	(0.314)	1.618 ***	(0.311)
Statistics	N = 265 F(11,253) = 15.990 $p < 0.001$ $R^2 = 0.410$ Adj $R^2 = 0.384$		N = 265 F(11,253) = 18.613 $p < 0.001$ $R^2 = 0.447$ Adj $R^2 = 0.423$		N = 265 F(11,253) = 20.288 $p < 0.001$ $R^2 = 0.469$ Adj $R^2 = 0.446$		N = 265 F(11,253) = 20.944 $p < 0.001$ $R^2 = 0.477$ Adj $R^2 = 0.454$	

Note: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$.

4. Discussion

The IAQ is a topic of increasing interest in green and energy-renovated buildings [25] and provides a compelling opportunity for the building industry; human health has recently emerged as a priority, as reflected in the Green Building Certification Program [7]. The purpose of this research was to understand whether the IAQ certification can influence people's willingness to consume. From the above results, it is shown that there is a significant correlation between them.

Mothersbaugh et al. [26] stressed that the factors that affect consumer behavior could be summarized into two types: external and internal influences. The IAQ cognition and display discussed in this research can be regarded as the internal influence factors of consumer perception, attitudes, and self-concepts.

Indeed, the empirical survey results confirm that IAQ-certified places have certain standards and continuous public disclosure of information, which is enough to change the willingness of the people to consume. In addition, the survey results also show additional influencing factors, such as gender, knowledge of the regulations, and living area, etc. These additional factors are mostly related to personal perceptions and objective conditions in Taiwan.

5. Conclusions

The WHO continuously emphasizes IAQ determinants on human health and the potential existence of harmful pollutants released from indoor sources [8]. The Taiwan Government, in 2011, enacted the "Indoor Air Quality Act" and continues to maintain the air pollution standards and related operating directions. Moreover, The TW EPA began promoting IAQ certification in 2021 and adopted a self-management approach to encourage various places to apply for the certification.

The survey conducted by this research found that certified places can indeed increase people's willingness to consume, and the certification can comply with international standards, as well as continuously monitor and disclose information—both of which are important factors. These findings also partially verify the three hypotheses proposed in this research. Concurrently, the results of this study are only applicable within the scope of the investigation and represent some regional findings; however, they retain a certain reference value. Similarly, these findings are partly different from previous past IAQ-related findings because other surveys mainly focused on exploring the possible symptoms of people in indoor spaces and their perception of the IAQ. This research links the public's perception of the IAQ with potential consumer behaviors, so these findings can indeed serve as a reference for business places, corporations, and the government.

According to the results of this research, compared with the current IAQ certification promoted by the Taiwan Government, there are two shortcomings that need to be further improved: firstly, the certified pollutant testing project excludes $PM_{2.5}$, which is currently an important source of air pollution and is also a common international air pollutant setting standard; secondly, in the process of applying the certification, the continuous testing requirement was canceled—only a simple mark shows the IAQ status. The biggest problem with this approach is that it is difficult to know whether the IAQ of places has changed over time and if the public has immediate access to IAQ information.

With today's modern lifestyle, people spend a greater amount of time indoors and often visit various indoor places. The Taiwan Government has promoted IAQ for ten years. Although there are still some shortcomings that need to be improved, the Taiwan Government still intends to move forward. Accordingly, the effectiveness of the currently implemented IAQ self-management certification in Taiwan remains to be further verified by more research.

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Appendix A. The IAQ Certification and Consumers' Willingness Questionnaire

Survey Site ☐Banqiao ☐Wuri

1. Basic Information

1.1 Gender ☐male ☐female

1.2 Age ☐ < 20 years old ☐ 21–30 years old ☐ 31–40 years old ☐ 41–50 years old ☐ 51–60 years old ☐ 61 years old and above.

1.3 Marriage ☐ Married ☐ Unmarried

1.4 Education ☐Junior High school ☐High school ☐College ☐University ☐Master or PhD

2. The Practical Experience and Knowledge of IAQ Scale Section

2.1 Do you have symptoms of air allergy? ☐Yes ☐No

2.2 Have you ever heard of air quality-related issues?

☐News media ☐Newspapers and magazines ☐Television

☐Government propaganda ☐Related websites ☐Tell from family and friends ☐Education and training ☐None

2.3 Do you know that the government has enacted the "Indoor Air Quality Act"? ☐Yes ☐No

2.4 Do you know those indoor air pollutants?

☐Carbon monoxide (CO) ☐Carbon dioxide (CO2) ☐Ozone (O3) ☐Formaldehyde

☐Total volatile organic compounds (TVOC) ☐Bacteria ☐Fungi ☐Suspended particulates (PM_{10})

☐Fine suspended particles ($PM_{2.5}$) ☐None

2.5 Do you have the following symptoms of physical discomfort indoors?

☐Dizziness ☐Dry eyes (itch) ☐Stuffy nose ☐Runny nose ☐Sneezing ☐Cough ☐Dry throat ☐Body neck, shoulder, back pain or stiffness ☐Dry skin ☐Chest tightness ☐Tiredness ☐Drowsiness ☐Lack of concentration ☐Tight nerves ☐None

2.6 Do you know that the government currently regulates the indoor air quality of the following public places?

☐College ☐Library ☐Medical institution ☐Annuity institution ☐Social welfare institution ☐Government office ☐Railway station and air station ☐MRT station ☐Exhibition room ☐Shopping mall ☐Financial institution ☐Museum/art gallery ☐Performance hall ☐Movie theater ☐KTV ☐Sports center ☐None

3. The Certification Cognition Scale Section

3.1 Do you agree that all public places should be marked with a healthy indoor air quality label, and a grading system should be adopted to show different levels of indoor air quality? (1 to 5, 5 = strongly agree)

3.2 In your opinion, should the healthy indoor air quality labels used in various public places in the future be divided into several levels?

☐1 level (passed) ☐2 levels (normal/excellent) ☐3 levels good/excellent/excellent)

3.3 Do you think that to mark the indoor air quality mark in public places, the design must be combined with relevant international air quality certification standards? (such as WELL healthy building certification standards) (from 1 to 5, 5 = strongly agree)

3.4 In the future, if the indoor air quality mark is to be displayed in public places, which authority do you expect to review and issue?

☐A fair third party with professional testing equipment ☐Indoor Environmental Quality Association ☐Local Environmental Protection Bureau ☐Central Environmental Protection Agency ☐All of the above

4. The Certification Displays Scale Section

4.1 Do you think that to obtain the certification of the healthy indoor air quality mark in public places, air quality monitors and display boards are installed at the entrance and exit. These are necessary conditions for applying for the certification? (from 1 to 5, 5 = strongly agree)

4.2 Do you agree to replace the original government-regulated test result poster with a healthy air quality label in the future? (from 1 to 5, 5 = strongly agree)

4.3 What other types of public places do you think should be given priority to obtain relevant indoor air quality testing or certification in the future?

☐Kindergarten ☐Elementary, Junior High, and High School ☐Children's Recreation Center ☐Gym ☐Long-term care Center ☐Office Building ☐Post Office ☐Restaurant ☐Hotel

5. The Willingness to Consume at Certified Places Scale Section

5.1 Are you willing to pay a higher fee to go to public places certified by the healthy indoor air quality mark? (from 1 to 5, 5 = strongly agree)

5.2 If there is a gym that has obtained the "Healthy Indoor Air Quality Mark" certification, would you be more willing to consume? (from 1 to 5, 5 = strongly agree)

5.3 If there is a kindergarten certified with the "Healthy Indoor Air Quality Mark", would you be more willing to send your children to school? (from 1 to 5, 5 = strongly agree)

5.4 If there is a long-term care center certified by the "Healthy Indoor Air Quality Mark", would you be more willing to be included as a nursing facility? (from 1 to 5, 5 = strongly agree)

References

1. The Indoor Air Quality Information Network. Available online: https://iaq.epa.gov.tw/indoorair/introduction_importance.aspx (accessed on 1 September 2021).
2. Steinemann, A.; Wargocki, P.; Rismanchi, B. Ten questions concerning green buildings and indoor air quality. *Build. Environ.* **2017**, *112*, 351–358. [CrossRef]
3. Kozielska, B.; Mainka, A.; Zak, M.; Kaleta, D.; Mucha, W. Indoor air quality in residential buildings in Upper Silesia. *Poland Build. Environ.* **2020**, *177*, 106914. [CrossRef]
4. WHO. *The Right to Healthy Indoor Air. Report on WHO Meeting: Bilthoven, Netherlands, 15–17 May 2000*; WHO: Copenhagen, Denmark, 2000.
5. Introduction to Indoor Air Quality. Available online: https://www.epa.gov/indoor-air-quality-iaq/introduction-indoor-air-quality (accessed on 1 September 2021).
6. Hawkins, V.R.; Marcham, C.L.; Springston, J.P.; Miller, J.; Braybrooke, G.; Maunder, C.; Feng, L.; Kollmeyer, B. *The Value of IAQ: A Review of the Scientific Evidence Supporting the Benefits of Investing in Better Indoor Air Quality*; AIHA®Ergonomics Committee: Falls Church, VA, USA, 2020.
7. Licina, D.; Langer, S. Indoor air quality investigation before and after relocation to WELL-certified office buildings. *Build. Environ.* **2021**, *204*, 108182. [CrossRef]
8. Settimo, G.; Manigrasso, M.; Avino, P. Indoor Air Quality: A Focus on the European Legislation and State-of-the-Art Research in Italy. *Atmosphere* **2020**, *11*, 370. [CrossRef]
9. Umaroğulları, F.; Seitablaiev, M.O. Regulations Regarding Indoor Air Quality. In Proceedings of the 14th International Conference "Standardization, Protypes and Quality: A Means of Balkan Countries' Collaboration", Tirana, Albania, 21 September 2018.
10. Palacios, J.; Steele, K.; Tan, Z.; Zheng, S. Human health and productivity outcomes of office workers associated with indoor air quality: A systematic review. *MIT Cent. Real Estate Res.* **2021**. [CrossRef]
11. Tsai, W.-T. Overview of Green Building Material (GBM) Policies and Guidelines with Relevance to Indoor Air Quality Management in Taiwan. *Environments* **2018**, *5*, 4. [CrossRef]
12. Yang, W.-T.; Chiang, C.-M.; Ho, M.-C.; Chen, J.-L.; Lo, S.-C. Indoor Air Quality and Its Determinants in Taiwan Child Care Centers. *J. Archit.* **2011**, *75*, 61–80.
13. Lee, M.J.; Shih, W.-C. Discussion on Indoor Air Quality in Different Space Plan in Dental Clinics. *J. Archit.* **2019**, *110*, 33–48.
14. Huang, Y.-T.; Chen, Y.-K. Methods for the Diagnosis of Indoor Environment Quality on Health Affection, Evaluation in the Research Building Type of Taiwan. *J. Archit.* **2010**, *73*, 143–159.
15. Hu, C.-P.; Lin, H.-K.; Cheng, J.-H. The Study of the Cognition and Evaluation of the Indoor Air Quality Management in the Department Stores-Take the Shin Kong Mitsukoshi Xinyi Place as an Example. *J. Prop. Manag.* **2019**, *10*, 13–23.

16. Hu, C.-P.; Cheng, J.-H. The Study of the Cognition and Management Strategies of the Indoor Air Quality in the Living Places. *J. Prop. Manag.* **2020**, *11*, 1–13.
17. Goldin, L.J.; Ansher, L.; Berlin, A.; Cheng, J.; Kanopkin, D.; Khazan, A.; Kisivuli, M.; Lortie, M.; Peterson, E.B.; Laura Pohl, L.; et al. Indoor Air Quality Survey of Nail Salons in Boston. *J. Immigr. Minority Health* **2014**, *16*, 508–514. [CrossRef] [PubMed]
18. Shang, Y.; Li, B.; Baldwin, A.N.; Ding, Y.; Yu, W.; Cheng, L. Investigation of Indoor Air Quality in Shopping Malls during Summer in Western China using Subjective Survey and Field Measurement. *Build. Environ.* **2016**, *108*, 1–11. [CrossRef]
19. Langer, S.; Ramalho, O.; Le Ponner, E.; Derbez, M.; Kirchner, S.; Mandin, C. Perceived Indoor Air Quality and Its Relationship to Air Pollutants in French dwellings. *Indoor Air* **2017**, *27*, 1168–1176. [CrossRef] [PubMed]
20. Wu, Y.; Lu, Y.; Chou, D. Indoor Air Quality Investigation of a University Library Based on Field Measurement and Questionnaire Survey. *Int. J. Low-Carbon Technol.* **2018**, *13*, 148–160. [CrossRef]
21. Wong-Parodi, G.; Dias, M.B.; Taylor, M. Effect of Using an Indoor Air Quality Sensor on Perceptions of and Behaviors toward Air Pollution (Pittsburgh Empowerment Library Study): Online Survey and Interviews. *JMIR Mhealth Uhealth.* **2018**, *6*, e8273. [CrossRef] [PubMed]
22. Huizenga, S.C.; Zagreus, L.A.; Arens, E. Air Quality and Thermal Comfort in Office Buildings: Results of a Large Indoor Environmental Quality Survey. *Proc. Healthy Build.* **2006**, *3*, 393–397.
23. Saleem, M.; Kausar, M.A.; Khatoon, F.; Anwar, S.; Shahid SM, A.; Ginawi, T.; Hossain, A.; Al Anizy, A.A.S.A.; Alswaidan, M.A.A.; Aseeri, A.S.; et al. Association between Human Health and Indoor Air Pollution in Saudi Arabia: Indoor Environmental Quality Survey. *J. Pharm. Res. Int.* **2020**, *32*, 57–66. [CrossRef]
24. Yap, H.S.; Roberts, A.C.; Luo, C.; Tan, Z.; Lee, E.H.; Thach, T.Q.; Kwok, K.W.; Car, J.; Soh, C.K.; Christopoulos, G. The Importance of Air Quality for Underground Spaces: An International Survey of Public Attitudes. *Indoor Air* **2021**. [CrossRef] [PubMed]
25. Yang, S.; Pernot, I.G.; Jorin, C.H.; Niculita-Hirzel, H.; Perret, V.; Licina, D. Energy, indoor air quality, occupant behavior, self-reported symptoms and satisfaction in energy-efficient dwellings in Switzerland. *Build. Environ.* **2020**, *171*, 106618. [CrossRef]
26. Mothersbaugh, D.L.; Hawkins, D.I.; Kleiser, S.B. *Consumer Behavior: Building Marketing Strategy*, 14th ed.; McGraw Hill: New York, NY, USA, 2020.