병원의 실내 공기 질 솔루션 선택에 영향을 미치는 요인들

Critical Factor on Selection Indoor Air Quality improving alternatives for healthcare projects

당원홍안[1] · 안용한[2*]
Dang Nguyen-Hong Anh[1] · Ahn, Yong-Han[2*]

Abstract : Indoor Air Quality is crucial in hospital projects to ensure the health and safety of patients, staff, and visitors. The research methodology comprises an comprehensive literature review, then a comprehensive questionnaire survey conducted among stakeholders involved in Vietnamese hospital projects. 15 variables were identified and categorized into four distinct groups, elucidating their influence on the adoption of advanced IAQ-enhancing technology. This study uses factor analysis, a mean score method and hypothesis test to analyze the factor result from the survey. two-step process, including an in-depth literature review and questionaire survey. The study's findings culminated in the ranking, examination, and categorization of these 15 variables, which were clustered into four essential categories: economic factors, design elements, governance strategies, and technical requirements. Additionally, the research explored viable solutions to improve indoor air quality in Vietnam's unique environmental context, examining the factors that impact the selection of such solutions. The study's outcomes yield practical recommendations for architects, engineers, and hospital administrators in enhancing IAQ within healthcare facilities. Furthermore, it presents a framework attuned to local environmental factors and building materials, contributing significantly to the existing body of knowledge on IAQ within hospital projects, particularly in the Vietnamese context.

키워드 : 임계 요인, 실내 공기 질, 의료, 병원, 녹색 사양
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1. Introduction

Among hospitals-related health risks, environmental factors play a key role; this accounting for different rooms' specific use, patients' vulnerability, and risk of overcrowding. For these reasons, air quality control in hospitals and in healthcare facilities in general deserves scientific attention. Health care is a unique built environment because their primary function is maintaining and restoring health. It can also be dangerous if an infected person is placed in a contagious environment. An increasing number of studies have shown the influence the hospital indoor environment has on patient recovery and staff's productivity. However, in many existing hospitals, the environment of care focuses on maximizing medical care efficiency, sometimes without considering the impact of design on patient and guest experience. IAQ is influenced by the concentration of microorganisms such as particulate matter, fungi, microbes, and infections. The IAQ in hospital is influenced by the air system, humidity, microbial load of external environment and the number of patients, visitors and workers as well as healthcare activities. To achieve IAQ, many solutions such as green building specifications, air filter, air purifier, sensor and ventilation control systems, e.g, have been used for stakeholders to consider. Existing research in IAQ improvement in healthcare projects reveals a notable research gap and lack of alternative orientation for stakeholders. Despite the acknowledged importance of IAQ for patient outcomes and staff well-being, research primarily focused on commercial buildings, and green healthcare projects remains limited. Our aim is to identify and prioritize the key factors that significantly impact the choice of IAQ improvement alternatives in Vietnam hospital projects.

2. Methodology

To effectively address the research questions described in the introduction, this study uses the following research methods: (1) extensive review of the relevant literature; (2) preliminary study; (3) development, dissemination, and collection of a structured questionnaire survey; and (4) rigorous data analysis. The research will mainly focus on examining the existing practices of influence factors in indoor air quality design among industry practitioners and their perceptions of the general advantages and potential contributions of innovative design solutions. The pilot study aimed to evaluate whether information collected from the literature was consistent with the current situation. The results of the survey have gone through the process of synthesizing, analyzing, and statistic test including Cronbach's alpha reliability test, KMO and Bartlett's Test of Sphericity, Total Variance Explained and Rotated Component Matrix. The outcome confirmed the feasibility of factor categorization and the existence of certain benefits and challenges in

1) 한양대학교 석사과정 스마트시티공학과
2) 한양대학교, 교수, 교신저자(yhahn@hanyang.ac.kr)

the real industry. 16 factors contributing to the process are described in Table 1.

3. Result

The total number of responses was 161. The individual respondents and companies are from metropolitans in different parts of Vietnam. The reliability test results show that Cronbach's coefficient of 0.788 in the questionnaire's adoption factors exceeded the 0.70 thresholds, respectively. As a result, the results of the Cronbach test confirm the reliability of the data collected for analysis. When conducting the factor analysis on benefit variables, the KMO value is 0.870 and the significance level of Bartlett's test is 0.00, which all prove the appropriateness of using factor analysis. The factor analysis extracted two factors in explaining approximately 62% of variances. Sixteen identified factors constitute the four principal components critical to the selection of strategies for improving IAQ within healthcare projects. The results show that the mean values of the variables are from 3.0 for 3.56to 4.0 for 3.97. The top five critical variables are: "T4 - compatible with medical function" (mean = 3.97); "D1 - project scale and planning" (mean = 3.95); "D2 - design purpose" (mean = 3.94); "E1 - initial cost" (mean = 3.91); "G1 - owner's requirement" (mean = 3.86), thus, considered as greatest obstacles in considering IAQ solution for hospital project in Vietnam.

Table 1. The factor identification and average score

CODE	FACTORS	CLARIFICATION	MEAN SCORE	RANK
E-1	Initial cost	• Cost of design and operation of the team; Cost of equipment purchase, transportation, and installation; Hiring third party (for executive design and testing, modeling IAQ); Certification registration fee.	3.91	4
E-2	Operating/ maintenance cost	• Life cycle costing of devices and additional building cost.; Annual maintenance cost for IAQ system and devices.	3.61	14
E-3	Technology transfer cost	• Cost of technology transfer or purchase; fees for technical support and training; intellectual property rights by product or by year.	3.61	15
D-1	Project Scale and Planning	• Project scale, site assessment, number of beds, specialties and Planning of subdivisions, landscapes, chains affecting the indoor environment.	3.95	2
D-2	Design purpose	• Design goal (human health/ energy efficiency) determines the interest and percentage of funds for IEQ. • Pre-design phase decides on specialists needed and technical approaching plan for IAQ which is shown in commissioning scope.	3.94	3
D-3	Schematic Design (SD)	• Effective ventilation needs to be included in drawings of architectural, interior, landscape, structural, MEP, HAVC. Collaboration between Design team leaders and IAQ Specialists.	3.83	6
D-4	Environment at construction site	• Including Physical, Biochemical, Microclimate around building area : Air Quality Index; • Characteristics of water sources, geology, and organisms.	3.76	8
G-1	Owner's requirement	• Each hospital project has specialties, depending on client's awareness, they can make specific IEQ requirements.	3.86	5
G-2	Commercial advantages	• Financial incentives, attracting investment and loan opportunities; Opportunities for cooperation and sponsorship from sustainable funds; Increase competitiveness and raise branding awareness as marketing tool	3.68	12
G-3	Future Adaptabilities	• National standard for indoor air quality TCVN 13521: 2022 - has been released for housing and public buildings. Soon, the national regulation would have been enacted. • IAQ tools are flexibility and adaptable for the development of construction technology.	3.75	10
G-4	Administration	• Requires highly qualified managers, management strategy for building system; Stakeholders engagement	3.73	11
T-1	Feasibility	• Capable of installation in accordance with Vietnamese engineering techniques and construction condition.	3.68	13
T-2	Operability	• Demand for pollution measurement data and usage behavior collecting;; database of material, technology, and product thoroughly.	3.76	9
T-3	Integrated capability	• Need an integrated design team and interoperability between tools; manage the effect of IA system installation on other engineering systems: HVAC - IAQ - Lighting - Acoustics - Fire - Communications, Plumbing, Mechanical…; Combine with other system for well-controlled in design, construction, and operation	3.81	7
T-4	Compatible with medical function	• The system must guarantee that it does not interfere with the hospital's medical needs, as well as the medical examination and treatment machinery and equipment.	3.97	1
T-5	Emissions	• Impact of IAQ solutions on total building energy consumption, operating and demolition emissions, and its environmental impact.	3.56	16

4. Conclusion

Consequently, this study aim to identify the critical factor on selection Indoor Air Quality improving solution for healthcare projects. A list of 16 variables constitute the four principal component of concerning for stakeholder have been developed based on literature review and factor analysis. This study contributes to the broader discourse on the need for IAQ in healthcare project development. By identifying and prioritizing critical factors for IAQ improvement, we pave the way for more informed choices in the adoption of advanced technologies, ultimately leading to healthier indoor environments in healthcare facilities. To promote effective collaboration, an integrated design team will proffer unified solutions according to articulated needs of investors, market demands, and the prevailing legal framework. We recommend further investigations to validate the applicability of these critical factors through in-depth case studies and assessments in different regions. It is imperative to recognize that the development of a sustainable building necessitates careful consideration of local contextual factors and a thorough exploration of national standards pertaining to construction practices, this research particularly in densely urban areas within Vietnam.

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