

A Mapping Model of the Sustainability Hospital Buildings in Post Occupancy Evaluation: A Bibliometric Analysis

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ABSTRACT

Post Occupancy Evaluation (POE) has proven to be an important tool for assessing interior environmental quality and a useful strategy for continuous building quality improvement in addition to standard tools. This study aims to provide an integrated evaluation model for occupant needs by investigating how the Sustainability Hospital Buildings are related to POE. This research employs a qualitative method with Bibliometric Analysis. The information used in this study was obtained by searching the keywords "Post Occupancy Evaluation" in the Scopus database from 2010 to February 2022. The identification of the time range resulted in the discovery of 305 documents. Overall, the sustainable Buildings scores were positively associated with intelligent buildings ($r= 0,584$). In addition, the sustainable Buildings had a significant relationship with low-energy buildings, low carbon building design, green building performance, and green buildings with correlation coefficients ranging from 0.5833 to 0.550. Concurrently, Hospital Building and sustainable building design showed a correlation ($r= 0,538$). Therefore, with the aspect of the sustainable Building in the hospital can determine a strategy for designing hospital buildings that produce results hospital management will be able to keep the building's quality, both in terms of indoor air quality and comfort.

Keywords: Post occupancy evaluation, Sustainability Building, Bibliometric, Hospital

INTRODUCTION

The complexity of the requirements for the growing need to provide high quality care in order to increase patient satisfaction has made building design increasingly important for healthcare facility organizations in recent years (1). Hospitals with high indoor environment quality can promote nosocomial infections that are hazardous to both patients and hospital staff, while hospitals with low indoor environment quality can hinder patient recovery and create an unpleasant work environment (2). The health of occupants will be impacted by issues such as inadequate ventilation, poor indoor air quality, chemical pollutants from indoor or outdoor sources, making people feel too cold or hot, traffic noise, and inadequate lighting (3). Furthermore, hospitals use the most energy of all public buildings because they are open 24 hours a day (4).

From the perspective of healthcare facilities, energy is a crucial component that is dependable, affordable, and sustainable for raising living standards, economic success, and growth (5). Buildings consume more than 40% of all the energy used in the world, and by 2050, that percentage is

expected to rise to 50%. (6). As a result, it is anticipated that buildings will be built in the future to be more airtight to conserve energy (7). In hospitals, safety is a structural variable that is influenced by patient health as well as staff physical safety, who are exposed to hazards that put them at risk for serious occupational illnesses as well as psycho-physical illnesses (8). When creating a healthy environment, it is crucial to take three factors into account: interior aesthetics, privacy, and comfort and control (9). Design of the building, temperature comfort, the visualization presented to visitors, space utilization, sound level strategic planning, and the ability to accommodate occupant demands all have a significant impact on comfort (10).¹

A design analysis method called Post Occupancy Evaluation (POE) is used to direct and evaluate the social and physical aspects of a building after it has been occupied (11). POE has also been demonstrated to be a significant tool for interior environmental quality assessment and useful strategies, in addition to standard tools, for continuous design quality improvement (12,13). As a result, the POE Technique can successfully incorporate environmental quality, thermal comfort, efficiency, environmental strategy, and occupant satisfaction by revealing the connections between key building

performance elements (14). Aspects of post-occupancy evaluation also relate to building physical standards, which take energy and thermal use into account (11).

The habits of the occupants that affect energy efficiency are frequently the focus of POE. It is easy to measure energy use and get a sense of how comfortable an occupant is on a thermal level, but it is more challenging to measure and get a sense of how comfortable they are on a ventilation level. Newcomers frequently underestimate the importance of proper ventilation. Buildings are becoming more airtight in order to use less energy for space heating; however, if the ventilation system is not checked and maintained by tenants, it will eventually be detrimental to the occupants' health and well-being due to exhaustion and stress (7,15). In addition, because it affects productivity and human health in the interior environment, sunlight is essential for building occupants. Green building grading systems may help raise awareness of the value of sunlight in buildings and improve the standard of the ambiance inside by giving points for capturing sunlight in structures (16). Architecture, temperature comfort, visitor perception, space utilization, noise management, and the ability to meet occupant needs all significantly affect overall comfort as a result (10).

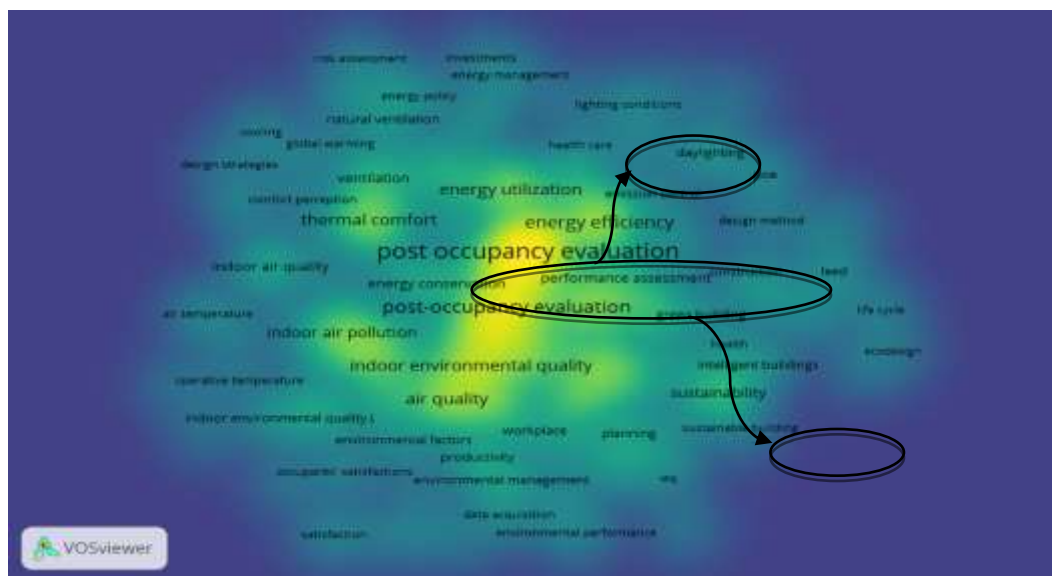


Figure 1. Visualization of Hospital Building in POE

Based on figure 1 taken based on data from Scopus which was published in 2010 to February 2022 with the keyword "Post Occupancy Evaluation" with a focus on the area of environmental and energy science, a total of 305 documents. After that, visualization using VOSviewer found that there were many studies using POE (yellow density visualization), but from this study it was seen that research in the health area was still lacking (bluish green density visualization). Based on the analysis above, it can be concluded that POE in hospitals is rarely carried out, in this finding it is mostly evaluated in shopping center buildings, hotels and offices. In addition, the authors identify that there is still a lack of study that focuses on sustainability, especially in terms of energy and the environment and sustainability with the POE method, when viewed from the visualization of the density, it is still small. Therefore, this study aims to provide an integrated evaluation model for occupant needs by investigating how the sustainable buildings in the hospital are related to POE.

MATERIALS AND METHODS

This study used qualitative literature review methods as well as a Bibliometric Analysis methodology, which entails a variety of activities such as collecting reference services data, reading and recording, and sustaining research materials. A literature review is an important activity in a research,

particularly in academic research with the aim of discovering theoretical and practical benefits. Every researcher conducts a literature review in order to lay the groundwork for assembling and developing a theoretical base, a conceptual model, and identifying tentative preconceptions, also recognized as research hypotheses. Concurrently, the researchers can organize, categorize, and apply a wide range of research literature on their topics.

Research approach and selection standards

This research strategy has been agreed upon by the Scopus databases as a whole. In order to find the study data, researchers searched the database of the renowned peer-reviewed database Scopus (<https://www.scopus.com>). When "Post Occupancy Evaluation" was used in the Scopus database search, 1.112 documents with publication dates spanning from 2010 to 2022 were discovered. Next, the topic areas "Environmental Science" and "Energy" were chosen in order to obtain 342 documents that matched the focus area the researchers were after. The study only looked at 305 documents that were published as journal articles and conference papers. All data were gathered in the same month, February 2022, to avoid the bias introduced by the database's expansion. The steps shown below (Figure 2) were taken in order to clearly outline the investigation's process.

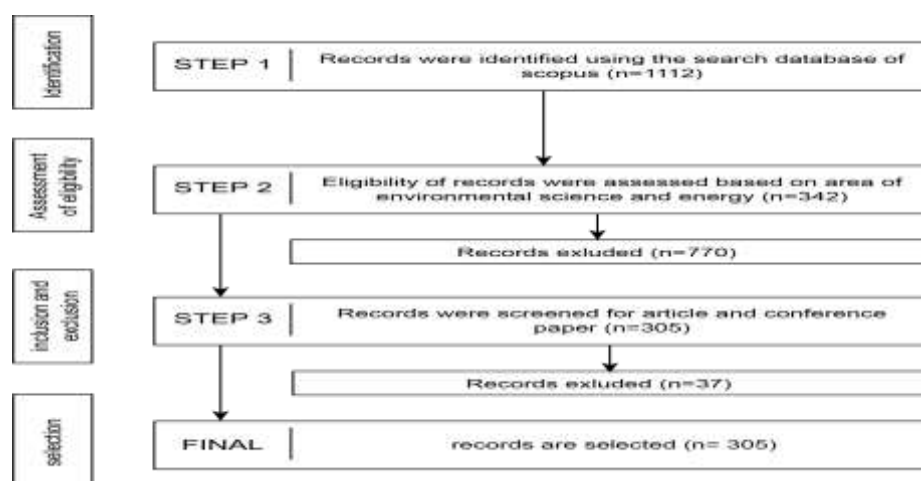


Figure 2. The Steps Searching and Selecting the Articles

The conclusion of this association was then used to direct additional research. in order to encourage additional investigation into POE using the Hospital Building Standards application. As part of the POE analysis, the most commonly used phrases were mapped using VOSviewer software. The title or author keyword served as the foundation for the Post Occupancy Evaluation. The following query was executed: TITLE-ABS-KEY (post AND occupancy AND evaluation) AND PUBYEAR > 2009 AND (LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "ENER")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp")).

Data extraction and quality assessment

Subject area and keywords were extracted from each article that had two reviews. It was also simpler to read and analyze the data since it was limited by the year and the English language. The methods employed, their limitations, as well as the overall participation rate and participation percentage, were screened. By comparing the two investigators' data collection forms, either the validity of the intentionally collected or intentionally retrieved data was confirmed. The next three quality assessment methods are representativeness, sample size, and relation of the articles under consideration.

Analysis of data

The NVivo 12 Plus software and the Vosviewer software were used for the study's data analysis. The correlation between indicators, variables, and keywords used in earlier studies was tested using the NVivo software. The conclusion from this correlation was then used to guide further study. When researching POE in the sustainable building of the hospital, The VOSviewer app was also employed to map the most commonly used keywords. It was done to facilitate future research on sustainable building in the hospital in POE. The researchers organized the parameters of evaluation and components for the bibliometric exploration using bibliometric investigations and mixed citations. A bibliographic coupling was used as a comparison measure by comparing the number of journal articles formed by two documents; co-occurrences aided in understanding the document set motifs supporting the investigation; and co-citations aided in identifying the conceptual framework of the study's subject. To develop and construct the figures and information gathered from the cited articles, the authors used co-occurrence assessment of keywords and co-citation source network analysis of POE to form groups and streams.

RESULTS AND DISCUSSION

Overview of publication output

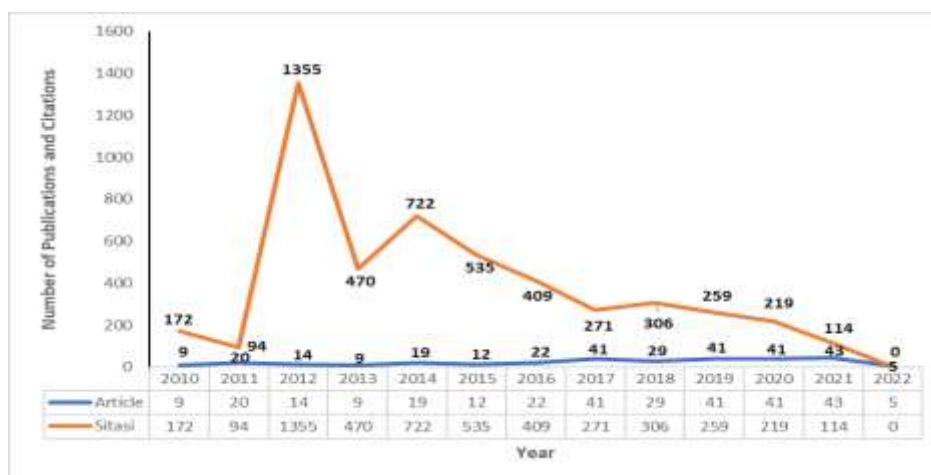


Figure 3. Number of publications and citations by year

In total, 305 publications examined Post Occupancy Evaluation in Hospital Building. Figure 3 depicts the evolution of research written with the theme of Post Occupancy in Hospital Building and published in Scopus between 2010 and 2022. In the development of research written on the POE theme published in Scopus in Figure 2, this research analyzed the annual trend in publications showing that in 2017-2021 there was an increasing trend, especially in 2021. 2012 has received the most citations in the last three years. Energy performance, Indoor Environmental Quality, Architectural design, Occupants' satisfactions, Green buildings, Green buildings, environment, Air quality, Thermal Comfort, Energy efficiency, Sustainable development, Energy utilization, Sustainability, environmental factors, emission control,

visual comfort, energy management, zero energy buildings were the most popular research topics in five years (2018-2022). The Increasing trend of POE in Hospital Building because the concerns about quality building, particularly in the indoor environment, are growing in popularity, owing largely to occupant comfort and energy expenditure (17). Moreover, relation to the POE approach in hospital building was developed in response to a greater understanding of the benefits and impacts that a healthy physical environment can provide to occupants and stakeholders measuring the quality of the physical environment (18). As a result, POE is often associated with the physical aspects of buildings, including energy and thermal considerations (11).

Country-based scientific production



Figure 4. Country-based scientific production

Numerous publications contributed to the development studies on post-occupancy evaluation in hospital buildings in 52 countries. These countries were arranged geographically, with the United States, the United Kingdom, China, Australia, Italy, Canada, Denmark, Malaysia, Spain, Singapore, Hong Kong, Egypt, the Netherlands, Sweden, and India at the top

(Figure 4). This map was made with "Biblioshiny," a web interface for the bibliometric package. America is in the first rank, the country with the most publications related to POE, namely 77 documents, followed by England with 71 documents, China with 34, Australia with 27 documents, and Italy with 17 documents.

Top 10 most global and cited publications (2010-2022)

Table 1. Article Distribution based on Citations

Title	Author and Year	Source	Citation
Predicted vs. actual energy performance of non-domestic buildings: Using post-occupancy evaluation data to reduce the performance gap	(19)	Applied Energy	473
Quantitative relationships between occupant satisfaction and satisfaction aspects of indoor environmental quality and building design	(20)	Indoor Air	319
Virtual reality as an empirical research tool - Exploring user experience in a real building and a corresponding virtual model	(21)	Computers, Environment and Urban Systems	175
Nonlinear relationships between individual IEQ factors and overall workspace satisfaction	(22)	Building and Environment	169
Green occupants for green buildings: The missing link?	(23)	Building and Environment	166
Occupant satisfaction in LEED and non-LEED certified buildings	(24)	Building and Environment	162
Gender differences in office occupant perception of indoor environmental quality (IEQ)	(25)	Building and Environment	150
Satisfaction of occupants toward indoor environment quality of certified green office buildings in Taiwan	(26)	Building and Environment	137
Completing the missing link in the building design process: Enhancing post-occupancy evaluation method for effective feedback for building performance	(27)	Building and Environment	101
Investigation on the impacts of different genders and ages on satisfaction with thermal environments in office buildings	(28)	Building and Environment	92

Table 1 categorizes articles according to the amount of citations in the title. From 2010 to 2022, the top ten most cited publications are shown in Table 1. This is employed to map the published papers that are most relevant to the POE topic. As a result, it is critical to emphasize that rankings are based on the articles cited. The publications that are published are frequently referred to in terms of environmental quality, building design, and building performance rooms. The number of article citations obtained in all databases has been internationally standardized (Scopus). Table 1 describes the researcher's analysis of the citations obtained in the article as a

whole. The three most frequently cited articles are "Predicted vs. actual energy performance of non-domestic buildings: Using post-occupancy evaluation data to reduce the performance gap" (n: 473) in 2022; article by (19) Article entitled "Quantitative relationships between occupant satisfaction and satisfaction aspects of indoor environmental quality and building design" (n: 319) in 2022; Article by (20) and the article entitled "Virtual reality as an empirical research tool - Exploring user experience in a real building and a corresponding virtual model" by (21) with a total of 175 citations in 2022.

Keyword mapping of the twenty most frequently used authors and keywords plus

Table 2. Keyword mapping of the twenty most frequently used authors

Ranking	Authors' keywords	Frequency	Ranking	Authors' keywords	Frequency
1 ^o	Post-Occupancy Evaluation	84	11 ^o	Indoor Environment	9
2 ^o	Indoor Environmental Quality	34	12 ^o	Green Building	9
3 ^o	Thermal Comfort	29	13 ^o	Comfort	7
4 ^o	Occupant Satisfaction	25	14 ^o	Overheating	7
5 ^o	Green Buildings	15	15 ^o	Building Performance Evaluation	6
6 ^o	Indoor Air Quality	11	16 ^o	Energy Performance	6
7 ^o	Sustainability	11	17 ^o	Monitoring	5
8 ^o	Energy Efficiency	9	18 ^o	User Satisfaction	5
9 ^o	Building Performance	9	19 ^o	Daylighting	5
10 ^o	Leed	10	20 ^o	Productivity	5

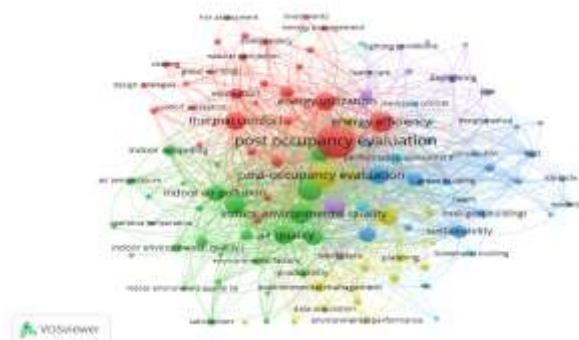


Figure 5. Mapping Authors' Keywords

Table 2 and Figure 5 show the most popular keyword mappings from the author and the data system (plus keywords). "Post-Occupancy Evaluation" (n = 84), "Indoor Environmental Quality" (n = 34), and "Thermal Comfort" (n = 29) were the authors' most frequently used keywords. In contrast, "Sustainability" (n = 11) and "Energy Efficiency" (n= 9) include the ten most frequently used keywords by authors.

The keywords should be able to recognize a trend for future studies and should cover the entirety of the study's scope. The keywords included in the study are acceptable as long as they provide an overall view of the topics discussed in the study, Occupant Satisfaction, Building Performance, Monitoring, Productivity, and Green Buildings.

Trending topics

Table 3. Mapping the author's 20 most frequently used keywords

Term	Range	Calculate	Weight Percent (%)	Term	Range	Calculate	Weight Percent (%)
energy	6	12172	2,52	design	6	5044	1,04
building	8	10844	2,24	comfort	7	4472	0,92
buildings	9	8874	1,84	air	3	4412	0,91
indoor	6	7442	1,54	environment	11	4290	0,89
evaluation	10	6750	1,40	occupant	8	3876	0,80
quality	7	6414	1,33	thermal	7	3630	0,75
occupancy	9	5972	1,23	satisfaction	12	3354	0,69
performance	11	5912	1,22	green	5	3016	0,62
post	4	5422	1,12	build	5	2362	0,49
environmental	13	5094	1,05	sustainable	11	1660	0,34

Table 3 presents the most frequently occurring words or topics. From the results of word frequency analysis using NVivo 12 plus it is known that energy (n=12172), building (n=10844), buildings (n=8874), inside buildings (n=7442), and evaluation (n=6750) are topics that most trending in POE. In addition, it also shows that design (n=5044), sustainable (n=1660), health (n=946), and environment (n=906) are included in the 20 most frequent topics in research. It was revealed that all the documents reviewed regarding the implementation of the use of POE in hospital buildings. However, from the 305 articles it was found that the discussion also often focused on the evaluation of buildings

(n=10844), while there was little analysis on health (n=946) and the environment (n=906).

Given that many hospital buildings are closely affected by energy and sustainability, the study's findings may reflect the impact of this situation. Furthermore, recent research has discovered that, inside the face of energy and sustainability management in hospital buildings, green buildings have the greatest benefits for building occupants, aside from assessing the energy performance of buildings and incorporating the Leadership Program in Energy and Environmental Design system in the future (29,30). Despite the significant environmental impacts of

such energy consumption, occupants' lack of thermal comfort is a common issue that can

lead to health complications and decreased productivity (31).

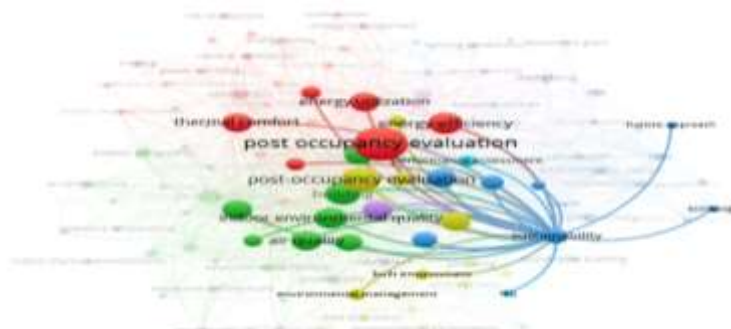


Figure 6. Visualization of the correlation in Sustainability Buildings

Furthermore, as shown in Figure 6, this finding shows that the visual representation depicts many of the sustainability correlations explained in this relationship, including thermal comfort, indoor environmental quality, air quality, performance assessment. The principle of Sustainable Hospital Building in terms of the energy efficiency, holistic approach, ecodesign, environmental management, and energy utilization. As a result, these elements must be considered in hospital management. A strategy is required to create a sustainable building impact in the design of hospital buildings. According to (32), all hospitals, particularly those in disaster-prone areas, must develop a framework strategy for assessing hospital building performance in the event of a disaster and post-disaster in the future with evaluation of building performance can be used in terms of sustainable buildings with post-disaster hospital reconstruction can be used holistically to assess, diagnose, and improve hospital building performance. Building performance evaluation in terms of sustainable building has three practical benefits. The first is design assistance in terms of improving future building procurement, the second is management assistance in terms of organizational efficiency for maintenance and operations, and the third is comparison assistance in the transition to sustainable production and consumption from the built environment (32). Furthermore, the ventilation system

strategy is critical in the environmental assessment of sustainable buildings. According to (33), each ventilation technique in buildings has flaws; however, it will have an impact on the occupants who interact in the building and are involved with the ventilation system, how well the strategy works in practice, and how well the occupants are aware of and understand ventilation. As a result, the evaluation of sustainable buildings demonstrates that it must be capable of evaluating human and environmental performance, as well as assessing the extent to which positive impacts in these two areas have been achieved and resulted in good results for the environment and people (34).

The long-term implications of a sustainable building will be felt. According to (35), there are three main points in terms of sustainable building. First, there is an impact on the environment where reduced energy consumption, increased area efficiency, more environmentally friendly transportation, materials, energy sources, and construction processes all have an impact directly so that sustainable principles for the design and construction of buildings contribute positively, especially in the long term by increasing. Second, there is an economic impact where increased output, increased activity, and innovative development are the result of energy efficient buildings as well as buildings that can easily adapt to future needs, making them appealing to healthcare facilities.

Third, it has a social impact by improving public services, increasing the welfare of building occupants, and contributing to the

improvement of social sustainability. As a result, the overall impact of the sustainable buildings extends beyond energy savings.

Table 4. The Hospital Buildings and Sustainable Buildings Research Topics.

	Code A	Code B	Pearson correlation coefficient
Hospital Buildings	Sustainable Buildings	intelligent buildings	0,584
	Sustainable Buildings	low-energy buildings	0,583
	Sustainable Buildings	low carbon building design	0,571
	Sustainable Buildings	green building performance	0,556
	Sustainable Buildings	green buildings	0,550
	Sustainable Buildings	sustainable building design	0,538
	Sustainable Buildings	building performance	0,527
	Sustainable Buildings	building construction	0,519
	Sustainable Buildings	occupant	0,519
	Sustainable Buildings	energy	0,517

Pearson correlation coefficient between total of sustainable buildings scores on intelligent buildings, low-energy buildings, low carbon building design, green building, sustainable building design, building performance, building construction, occupant and energy are shown in Table 4. According to the point-biserial correlation coefficient, overall the sustainable buildings scores were positively associated with intelligent buildings ($r= 0,584$). In addition, the sustainable buildings had a significant relationship with low-energy buildings, low carbon building design, green building performance, and green buildings with correlation coefficients ranging from 0,583 to 0,550. Concurrently, Hospital Building and sustainable building design showed a correlation ($r= 0,538$). There were relationships between building performance, building construction, and occupant.

Overall, Energy and environmental management are critical in hospital POE. The growing demand for high-quality care in hospitals necessitates energy management due to energy use and efficiency. According to (35), Energy management is an effective method for reducing energy inefficiency in buildings, particularly complex and high-efficiency buildings that do not perform as well as assumed, particularly during the concept-design-commission stage, because of a lack of feedback after the building is constructed. While (36), explained an energy efficiency strategy in hospitals in such a way that management can see that these facilities can carry out energy

efficiency activities and developments available from an environmental standpoint, the concept of building design by combining occupant surveys and building measurements is used to evaluate occupants' impression of environmental quality in the room, and compare the measurements with the applicable standards. And also (37), mention that adopting LED lamps can increase life expectancy, which is better and requires less maintenance duration, as well as better energy consumption than fluorescent lamps, which exist and must be uniformly arranged in the space to maintain adequate lighting up to the required standard.

In this recent study, environmental management is very important in hospital buildings in the setting of energy use. Hospitals are a rapidly growing segment of the health-care industry, resulting in a high demand for the construction and renovation of health-care facilities (38). The environment in the hospital, according to (39), is an important indicator for detecting occupant needs, such as the utilization of different lighting fixtures for various functions (reading, resting, etc.), light intensity, and control device. According to (40), the physical environment of the hospital not only affects the level of comfort and satisfaction of residents, but it also influences other important issues such as controlling bacterial and chemical contamination. Don't forget that managing noise sources and their location is equally important because they cause significant

noise incidents in the environment (41). An environmental management system that is built directly has a relationship with better results through changes in behavior and practices in carrying out care as mentioned by (42), that there are key areas in environmental development where it is significant in terms of providing support, including how occupants experience the environment, how the overall layout influences behavior, how sleep practices and hygiene behaviors can be changed, and how the relationships among residents are. Another article regarding environmental management in behavior change was also explained by (43), that residents can adapt to the environment in a multi-cultural community by having personal privacy, receiving good hospitality, and feeling the appropriate building atmosphere will show positive behavior. Inappropriate building affects and stimulates building-related symptoms or illness, and is even capable of disrupting the surrounding health environment; additionally, this situation has a significant impact on mental and social health (44). Therefore, supportive environmental management can promote positive occupant impacts in the face of progressive change (45).

The hospital environment has several things that must be considered, namely natural lighting, air quality, air pollution in buildings. Article by (46,47), explained that natural lighting has a positive association with a number of psychosocial variables because abundant natural light is a design feature most often associated with a pleasant atmosphere. In addition, the article from (48), states that efficient lighting design usually reduces solar heat gain which in turn can help and have a positive impact on minimizing energy bills, these factors have a significant impact on increasing lighting levels. significantly especially in patient rooms as well as on the daylight performance of indoor lighting and building thermal models. Finally, the environment of the hospital is a part of which most internal

and external users felt safe and comfortable while in or using the room (49).

This hypothesis in this research is fully confirmed to provide an integrated evaluation model for occupant needs by investigating how sustainability in hospital buildings are related to POE. We found that POE management can determine design strategies and the need for continuous evaluation of buildings so that productivity and satisfaction levels, both internal and external, are maintained. So that if the post occupancy evaluation is carried out again, the level of satisfaction and quality of the indoor environment, especially in the hospital, will be maintained. Maintaining POE in a sustainable manner can take advantage of a holistic approach, occupant satisfaction, energy performance and the environment. Researchers see that development is closely related to management models and occupancy rates. With this experience and development, it is hoped that hospital management will be able to maintain the quality of the building itself, both in aspects of indoor air quality and coziness. Furthermore, the creation of sustainability buildings in data analysis so that it is important to create definite calculation tools that can measure in terms of increasing levels of satisfaction and quality in the hospital environment which will also correlate in terms of increased productivity. This study will be a follow-up study by creating calculation tools in creating sustainable hospital buildings development in data analysis.

CONCLUSION

The study can be concluded based on the above explanation of the findings. First, the study's findings show that the Pearson correlation between the total score of the evaluation scale and POE can indicate an impact on aspects of intelligent buildings, low-energy buildings, low carbon building design, green building, sustainable building design, building performance, building construction, occupant and energy. Overall the sustainable buildings scores were

positively associated with intelligent buildings ($r= 0,584$). In addition, the sustainable buildings had a significant relationship with low-energy buildings, low carbon building design, green building performance, and green buildings with correlation coefficients ranging from 0,583 to 0,550. Concurrently, the hospital buildings and sustainable buildings design showed a correlation ($r= 0,538$).

Second, the implementation of post-occupancy evaluation is inseparable from the sustainable buildings (holistic approach, occupants, energy performance, environmental performance to produce user satisfaction). Therefore, with these aspects, the hospital can determine a strategy for designing hospital buildings that produce hospital management results in which will be able to keep the building's quality, both in terms of indoor air quality and comfort.

Declaration by Authors

Ethical Approval: Not Applicable

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