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RESEARCH ARTICLE

End-user evaluation for human-oriented healthy and sustainable hospital design: Two case studies

Gizem Can [1], Sehnaz Cenani [1]

[1] Istanbul Medipol University, School of Fine Arts, Design and Architecture, Department of Architecture, İstanbul, Türkiye

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Abstract

Sustainability reveals the importance of efficiently managing building life cycle processes within the scope of contemporary solutions like the circular and green economies. These solutions take a wider perspective, also caring for ecosystem resilience and human well-being. Hospitals, which include large and diverse groups of end-users, must consider human welfare, a core green economy goal, alongside strict green building requirements. It is believed that designing truly sustainable and healthy hospitals requires prioritizing end-users' health and wellbeing. This study investigates end-user perceptions of sustainability criteria within hospitals. It evaluates feedback from hospital end-users through two case studies. Data was collected from a total of 208 participants via a survey based on LEED v4 BD+C: Healthcare requirements, targeting long-term and short-term end-users in medium and large-scale hospitals. To calculate the average importance score for each statement according to the total number of responses, the index value based ranking method was used. The findings reveal that while both long-term and short-term hospital end-users prioritized criteria related to Indoor Environmental Quality (IEQ), their specific expectations varied according to the scale of the hospitals. When considering the opinions of short-term and long-term hospital users, it was found that short-term users prioritized the IEQ and Energy and Atmosphere (EA) categories, while long-term users focused more on the IEQ, Sustainable Sites (SS), and Material and Resources (MR) categories. These findings suggest that sustainable hospital designs should consider both end-user perspective and hospital scales. The findings aim to support the design of healthier healthcare buildings and contribute to the ongoing refinement of green building certification standards.

1. Introduction

Building construction is essential for sustainable development, yet the industry is responsible for consuming half of the world's physical resources [1] and has an enormous impact on gas emissions and climate change [2, 3]. Considering these significant environmental footprints, prioritizing sustainable building practices is essential. Sustainability is defined by the intersection of social, economic, political, and environmental issues [4], demanding a transdisciplinary approach to achieve sustainable development [5]. This necessity reveals the importance of efficiently controlling building life cycle processes within the

Correspondence Gizem Can gizem.can@medipol.edu.tr

scope of contemporary solutions like the circular and green economies.

The movement toward sustainability has led to the establishment of global standards, such as the UN`s "2030 Agenda for Sustainable Development" [6], and the emergence of various green building certification systems [e.g., Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), the WELL Building Standard (WELL)] [7]. These systems aim to protect user health, ensure efficient resource use, and minimize environmental impacts. Also, Bayhan and Polat [8] assert that green certified projects undertaken in developing countries are to be carefully examined to spread green building assessments and solutions.

Due to factors like extended operating hours, hospitals consume significant amounts of energy [9]. Also, the strategic management of facilities in these critical buildings is of paramount importance to a society that relies on effective healthcare services [10]. Hospitals, which include large and diverse groups of end-users, must consider human welfare, a core green economy goal, alongside strict green building requirements. While high scores in systems like LEED are considered indicative of a "green hospital", this does not always guarantee an ideal healthcare environment for patient health and well-being [11, 12]. It is believed that designing truly sustainable and healthy hospitals requires prioritizing end-users` health and wellbeing. Therefore, like the other buildings, it is highly valuable to evaluate hospitals through an integrated approach that considers both end-users and technical aspects. This approach is crucial for ensuring sustainability. Since green building certification systems generally focus on technical and measurable criteria, such as energy consumption and water use, end-user feedback is often not included in the certification process. One-way evaluation is suitable for objectivity and standardization. However, involving end-users, who use hospitals over long operational process during the building life cycle, and considering feedback is necessary to improve the evaluation process. All this feedback could contribute to improving the technical processes of these certifications. It is believed that end-users' energy habits, needs, priorities, and comfort perceptions can inform the addition of new criteria or the re-evaluation of existing ones for these certificates.

This study investigates user perceptions of sustainability criteria within healthcare facilities. Specifically, it addresses the potential differences in priorities between short-term end-users (patients and visitors) and long-term end-users (staff and professionals) regarding the specific requirements of the LEED v4 BD+C healthcare rating system. By focusing on end-user perspectives in two hospitals of different scales, this research aims to provide feedback for enhancing the human-centric focus of green building certification systems. This study aims to find answers to the following research questions:

- Which LEED healthcare criteria are perceived as important by end-users?
- Do the LEED healthcare criteria considered important by short-term end-users (such as patients and their relatives) differ from those prioritized by long-term end-users (such as doctors and nurses)?

2. Literature Review

The necessity for resource efficiency has placed focus on two related contemporary economic models: the circular and green economies. According to the European Environment Agency (EEA) [13], a circular economy emphasizes eco-design, repair, reuse, refurbishment, waste prevention, and recycling to increase resource efficiency and reduce negative environmental impacts. Meanwhile, a green economy takes a wider perspective, also caring for ecosystem resilience and human well-being (Fig. 1).

In response to these goals, the European Commission (EC) adopted the first "Circular Economy Action Plan (CEAP)" in 2015 [14]. CEAP aims to create global circularity efforts, focusing on high-potential sectors such as construction and buildings.

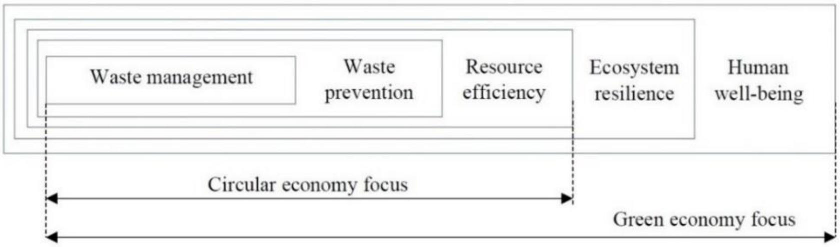

Fig. 1. Circular and green economy (adapted from [13])

The movement toward sustainable and livable spaces have driven the development of green building certification systems. The LEED certification system, for example, is widely preferred globally and specifically in Türkiye [1, 15]. Türkiye mandated that all hospitals with a bed capacity of two hundred or more must obtain LEED certification through a 2012 Ministry of Health legislation [16]. Due to this legislation, all medium and large-scale hospitals in Türkiye are required to have LEED certification. The LEED v4 BD+C healthcare rating system assesses facilities across eight categories, including Location and Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality [15].

In hospitals, addressing end-users is essential for evaluating well-being and health. The long-term end-users of hospitals are primarily health professionals, including doctors, nurses, and administrative staff, as defined by the International Labor Office [17]. In contrast, short-term end-users are patients, their relatives, and visitors.

Previous research has explored the application of green building and evidence-based design strategies in healthcare. Studies have analyzed certified facilities to determine if they prioritize criteria influencing patient wellbeing and recovery [11, 18, 19] or have focused on the relationships between indoor environmental quality and occupant satisfaction [20]. According to Camgöz-Akdağ et al. [21] green hospital design is a promising solution for improving patient well-being, an approach that focuses on incorporating environmentally sustainable features and practices across the hospital's buildings, infrastructure, and operations. Previous research confirms that staff in LEED-certified hospitals rate building performance higher than in non-certified facilities [22], and green features positively impact healthcare staff's perceptions of comfort and satisfaction [12]. Compared to the staff in silver-certified facilities, employees in gold-certified hospitals rated the buildings significantly higher across most performance variables, including overall building quality, overall comfort, and controllability [22]. Furthermore, a strong correlation exists between the green design aspects of a hospital and patient welfare [23].

When examining all the goals and actions developed on a global scale today, it becomes particularly important that both existing and new buildings ensure sustainability and support sustainable development. Therefore, it is essential to design and construct human-oriented, healthy, resource-efficient, livable, and sustainable buildings. Reviewed studies consistently highlight the importance of developing “Healthy Healthcare Buildings”. While our previous research has focused on the project management perspective of green hospital design (e.g., using AHP to evaluate criteria against cost, quality, and time) [24], this study shifts focus to incorporate end-user perspectives more directly. Current study emphasizes the priorities of short-and long-term end-users in the decision-making processes related to the design of green hospitals, offering a complementary but distinct approach to the same broader goal.

While existing literature examines overall satisfaction with green features [12, 22] or the impact of design on patient welfare [23], a notable research gap exists in the systematic evaluation and ranking of specific LEED healthcare certification criteria based directly on the perceived importance by end-users. No identified study has specifically asked end-users to quantify the importance of individual criteria within the LEED v4 BD+C healthcare system. This quantification is necessary to determine if the criteria prioritized by designers and developers align with the needs of the people who use the buildings daily. Furthermore, although some studies investigate either patient wellbeing or staff wellbeing, none of them directly compare the differential priorities of these two distinct end-user groups (short-term vs. long-term) within hospitals of varying scales.

3. Methodology

The aim of the survey was to reveal the requirements for designing human-oriented, sustainable, and healthy healthcare buildings according to the priorities of end-users of hospital buildings. The questionnaire was constructed using data from the LEED Healthcare certification system. This system is one of the most preferred green building certification systems in Türkiye and was made mandatory by the Ministry of Health in 2012 [25].

A questionnaire was used to collect data to gather structured, reliable information from participants of two hospitals (Fig. 2). According to the Turkish healthcare legislation [26], hospitals are classified into three categories: small-scale hospitals with 99 or fewer beds, medium-scale hospitals with 100 to 499 beds, and large-scale hospitals with 500 or more beds. Two hospitals located in Istanbul were chosen as case studies through a purposive sampling method. This approach allows researchers to explore complex issues in depth by focusing on information-rich cases that provide detailed contextual insights [27]. The selected hospitals were classified according to the national hospital size regulation. They represent different hospital scale categories, as defined by national regulations, and offer appropriate contexts for evaluating the applicability of sustainability criteria in relation to user diversity and physical infrastructure. The first case study was conducted in a medium-scale hospital, referred to in this study as Hospital A (H*A*), which has thirty-three different medical units and a capacity of 100 beds. The second case study was conducted in a large-scale hospital, referred to in this study as Hospital B(H*B*), which has eighty-four different medical units and a capacity of 810 beds.

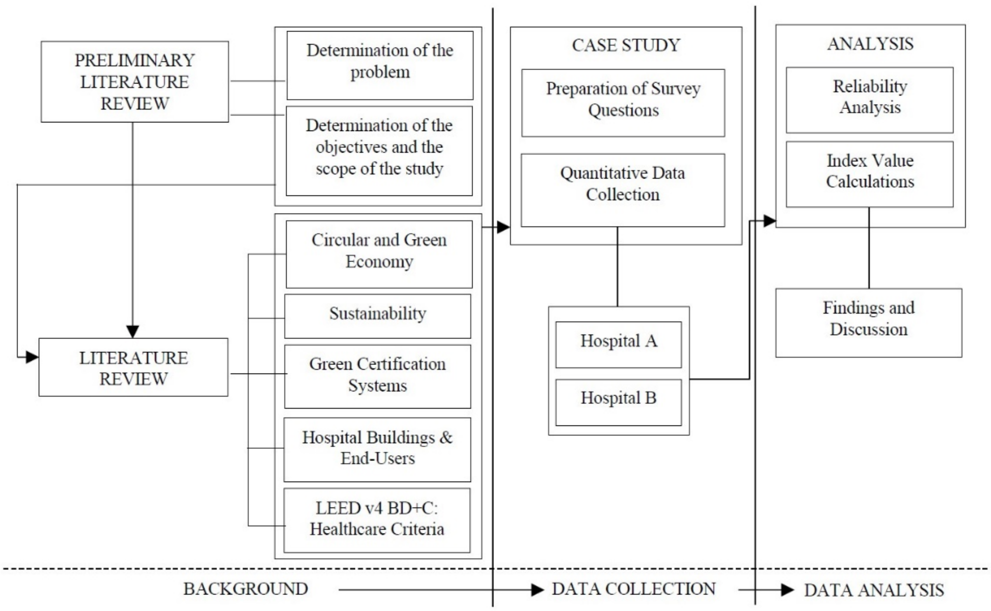

Fig. 2. Methodological flow chart of the study

The questionnaire was administered face-to-face to short-term hospital users and a portion of long-term users over a period of two months. During this process, the technical details related to the LEED healthcare certification system were clearly explained to participants to ensure proper understanding. Due to time constraints, for some long-term users such as doctors, the questionnaire, along with explanatory notes and the authors' contact information, was left with the participants, and responses were collected in person later. This method helped to prevent any loss of information or misunderstandings related to technical content during the administration of the questionnaire. The questionnaire was structured into two sections, the first of which was designed to collect demographic information from the respondents. Five questions in this section aimed to collect information defining the end-user type. The second section of the questionnaire was composed of 71 statements, based on LEED v4 BD+C: Healthcare requirements. These statements were constructed according to eight categories (location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation, regional priority) used in the LEED healthcare rating system. The statements were designed using a 7-points Likert scale. The respondents were requested to indicate the importance of each statement by selecting one of seven items, in which 1 indicates that the related statement is considered the least important, and 7 indicates that it is considered the most important. G* Power is used to calculate the minimum number of respondents needed to conduct the study [28]. The smallest sample number was calculated as 105 at the 95% confidence interval and 5% margin of error for seventy-one statements based on seventy-one requirements from the LEED healthcare rating system. 105 respondents from H*A* completed the questionnaire, but two were not properly completed, thus only 103 were used for analysis. 105 respondents from H*B* completed the questionnaire. A total of 208 participants participated in the study. All statements in the scale used in this study were developed by fully adapting the statements from the categories and sub-categories required for organizations seeking LEED certification for healthcare buildings [15]. Since the statements in the survey were based on LEED v4 BD+C: Healthcare requirements, a new scale was not developed, no pilot study was conducted prior to the survey.

The International Labor Office`s Guide was used to define long-term and short-term end-users of hospitals [17]. While 60% of participants in H*A* were long-term end-users (healthcare professionals like medical and pharmaceutical technicians, nursing, and midwifery associate professionals; personal care workers in health services such as home-based personal care workers; administrative and commercial managers such as human resources, finance managers; other service providers), this rate was 64% in H*B*. The remaining participants were short-term end-users (patients, patient relatives, and visitors) at both hospitals. To start with, for the reliability analysis of the survey, Cronbach's alpha reliability coefficient α, which is a frequently used method in literature, was used [29]. The Cronbach alpha value (α) was calculated as 0.98. As a rule of thumb, if $\alpha \geq 0.9$, then the answers are accepted as reliable and internal consistency is accepted perfect [30]. The relationship between Cronbach's alpha value and internal consistency was determined via Microsoft Excel regarding Polat et al.'s [30] study which is based on the study conducted by [31]. To calculate the average importance score for each statement according to the total number of responses, the index value based ranking method was used. This is because the responses could have been gathered from numerous participants in a short period of time to evaluate many statements. This method was preferred over ranking methods and tools like the Analytic Hierarchy Process (AHP) or Importance-Performance Analysis (IPA) primarily because of its simplicity, its ability to incorporate respondent consensus, and the specific nature of the data collected. The AHP is a complex Multi-Criteria Decision Analysis (MCDA) method, which requires respondents to perform pairwise comparisons. For a large-scale survey involving many statements and many responses, AHP is not suitable and resource intensive. Therefore, the index value based ranking method was selected. This method expresses the score obtained with the standard deviation and arithmetic mean value [32, 33]. A widely recognized weakness of using a weighted average is that it does not consider the degree of variation between individual responses. However, a smaller variation between individual responses will give a better quality to the weighted average value. Therefore, when two factors have the same or very close mean values, the factor with smaller variation should be given a higher rank. The typical technique used to reduce the weakness of ranking attributes according to the weighted mean value is the application of a measure called the coefficient of variation, which is the weighted mean divided by the standard deviation [32]. Therefore, effective assessment of the ranking of attributes should consider both the weighted mean and the coefficient of variation. Hence, the combined value of the weighted mean and the coefficient of variation can be used to rank the importance among all the utility factors. In this study, the index value based ranking method, used by [32], was applied as:

$$IV_i = \bar{x}_i + \frac{\bar{x}_i}{\delta_i} \tag{1}$$

where $\bar{x}_i$ represents arithmetic mean of each statement *I*; δ_i denotes the standard deviation of the significance score for statement *i*; IV_i denotes the index value based ranking method of statement *i* (Equation 1).

4. Findings and Discussion

By analyzing all the responses using the index value based ranking method, considering the responses from both short-term and long-term end-users of H*A* and H*B*, the top 10 answers from each group were identified. Based on the top 10 answers from all groups, 26 out of 71 statements from LEED v4 BD+C were identified as common responses (Table 1).

Table 2 shows the standard deviation and arithmetic mean of the top 10 statements for H*A*, which are used to calculate the index values for both short-term and long-term end-users, while Table 3 presents these values for H*B*.

A comparison of responses from H*A*'s and H*B*'s short-term and long term end-users is presented in Table 4. This table shows the importance of each statement across the same user groups in different hospitals. L5, L7, L8, L14, L16, L19, L21, L22, and L23 are among the top 10 statements for short-term end-users in both hospitals. Additionally, L1 is the most important statement for H*A*, while it ranks 16th for H*B*. On the other hand, L8, L12, L15, L17, L19, L21, L25, and L26 appear in the top 10 statements for long-term end-users in both hospitals. Furthermore, L11 is the most important statement for H*A*, while it ranks 15th for H*B*.

According to Table 4, the results reveal that short-term end-users, who spend less time in the hospital compared to long-term users and use the facilities of the hospital for a brief period, prioritize the L1, L2, L3, L15, L16 and L19 statements. When evaluated by hospital scale, L1, L2, and L3 (*EA* and *WE* categories) are the most important criteria for medium-scale hospital short-term end-users. In contrast, L15, L16, and L19 (*MR*, *LT*, and *SS* categories) are the most important for large-scale hospital short-term end-users. The findings show that the most important statement for H*A*'s short-term end-users is L1- *"The hospital/healthcare buildings should have a demand response program"*. For H*B*'s short-term end-users, the most important statement is L16- *"Material content reports of the most used materials in hospital buildings should be prepared, and it should be determined whether they are suitable for the environment/health"* (Table 4). On the other hand, long-term users who are working at the hospital, using the facilities of the hospital daily and commuting every day, prioritize the L11, L12, L13, L15, L19 and L24 statements. When these statements are assessed, L11, L12 and L13, which belong to the *EA*, *LT* and *MR* categories, are the most important criteria for medium scale hospital short-term end-users. Additionally, L15, L19 and L24, which belong to *LT* and *SS* categories, are the most important criteria for large scale hospital short-term end-users (Table 4).

Table 1. Statements selected by both long-term and short-term end-users

LEED Main Category	Code	LEED statements
Energy and Atmosphere (EA)	L1	The hospital buildings should have a demand response program.
	L2	Refrigerator cabinets used in hospital buildings should be chosen so that they do not damage the ozone layer and do not affect global warming.
Water Efficiency (WE)	L3	The sanitary ware/battery/electrical devices used in the hospital buildings should be chosen to minimize water consumption.
Material and Resources (MR)	L4	A waste management plan should be prepared to be implemented during the construction and demolition phases of hospital buildings.
EA	L5	To reduce the environmental and economic damage of excessive energy use in hospital buildings, building energy performance should be increased.
Indoor Environmental Quality (IEQ)	L6	The materials used indoors in hospital buildings should be low emission.
	L7	Natural and mechanical ventilation in hospital buildings should be planned according to international standards.
Sustainable Sites (SS)	L8	A greenfield area should be created by landscaping and vegetation on the site of the hospital buildings.
MR	L9	In hospital buildings, management criteria should be established for how mercury-containing materials and/or products/devices will be recycled within the scope of the recycling system.
EA	L10	Renewable energy sources should be used in or around hospital buildings.
	L11	The design, construction and final operation of hospital buildings must meet requirements such as energy, water, indoor environmental quality, and structural durability.
Location and Transportation (LT)	L12	There should be a program that provides alternative transportation.
MR	L13	The chemical substance ratios in the contents of the furniture or coating materials used in hospital buildings should be determined, furniture and coating materials suitable for the environment and health should be used.
IEQ	L14	Polluted air circulation between indoor and outdoor air ventilation in hospital buildings should be minimized and clean air/carbon dioxide concentrations should be monitored inside the building.
LT	L15	The entrance to the hospital buildings must be within walking distance of the existing bus, tram, or public transport stops.
MR	L16	Material content reports of the most used materials in hospital buildings should be prepared, and it should be determined whether they are suitable for the environment/health.
SS	L17	In the construction of hospital buildings, soil erosion, waterway sedimentation and airborne dust should be controlled and pollution from construction activities should be reduced.
MR	L18	Recyclable materials should be collected in dedicated areas in the hospital building.
SS	L19	Wheelchair-accessible places of respite should be provided for staff, patients, and visitors in hospital buildings.
IEQ	L20	In hospital buildings, sound insulation, noise control and acoustic solutions should be applied effectively.
SS	L21	Necessary controls regarding environmental contamination should be carried out on the project site where the hospital buildings are built, and the health of the society should be protected by eliminating environmental contamination.
IEQ	L22	Before/during the opening of hospital buildings, it should be tested whether they have adequate indoor air quality.
WE	L23	The water contents used in the heating-cooling systems in hospital buildings should be checked and choices should be made to reduce water consumption.

Table 1. Cont'd

LT	L24	There should be sufficient off-street parking space in hospital buildings, vehicles should not be parked on the street.
MR	L25	Hospital buildings should be designed for flexibility, sustainability, and ease of future adaptation.
IEQ	L26	Thermal comfort controls for heating, ventilation and air conditioning systems and building envelope systems in hospital buildings should be planned and implemented in accordance with international standards.

Table 2. Top 10 LEED requirements selected by H*A* short-term and long-term end-users

H*A*: Short-term end-users				H*A*: Long-term end-users			
Code	δ	$\bar{x}$	*IV*	Code	δ	$\bar{x}$	*IV*
L1	1.1	6.1	11.7	L11	0.9	6.3	12.9
L2	1.1	6.1	11.5	L12	1.1	6.4	12.4
L3	1.2	6.3	11.4	L13	1.0	6.2	12.2
L4	1.2	6.1	11.2	L14	1.0	6.2	12.1
L5	1.2	6.1	11.1	L15	1.2	6.3	11.8
L6	1.2	6.1	11.1	L16	1.1	6.1	11.7
L7	1.2	6.1	11.1	L17	1.2	6.3	11.7
L8	1.2	6.1	11.0	L6	1.1	6.0	11.7
L9	1.2	6.0	10.9	L2	1.1	6.0	11.7
L10	1.3	6.1	10.9	L18	1.2	6.3	11.6

Table 3. Top 10 LEED requirements selected by H*B* short-term and long-term end-users

H*B*: Short-term end-users				H*B*: Long-term end-users			
Code	δ	$\bar{x}$	*IV*	Code	δ	$\bar{x}$	*IV*
L16	0.5	6.6	18.7	L15	0.5	6.7	19.2
L15	0.6	6.8	18.2	L19	0.6	6.7	18.7
L19	0.7	6.7	17.0	L24	0.7	6.7	16.6
L20	0.6	6.6	16.8	L25	0.8	6.4	14.3
L7	0.7	6.6	15.6	L8	0.9	6.4	13.9
L14	0.7	6.5	15.5	L7	0.9	6.3	13.7
L21	0.8	6.5	15.0	L21	0.9	6.5	13.5
L8	0.8	6.5	15.0	L26	0.9	6.3	13.3
L22	0.8	6.6	14.5	L17	1.0	6.4	13.2
L23	0.8	6.3	14.1	L12	1.0	6.5	13.1

Table 4. Comparison of short-term and long-term end-users' statements: H*A* vs. H*B*

Short-term end-users: H*A* & H*B*					Long-term end-users: H*A* & H*B*				
Code	H*A*:*IV*	Rank	H*B*:*IV*	Rank	Code	H*A*:*IV*	Rank	H*B*:*IV*	Rank
L1	11.7	1	11.4	16	L2	11.7	6	10.7	15
L2	11.5	2	11.6	15	L6	11.7	6	11.1	14
L3	11.4	3	12.7	12	L7	10.4	11	13.7	6
L4	11.2	4	11.7	14	L8	11.5	8	13.9	5
L5	11.1	5	13.1	10	L11	12.9	1	10.7	15
L6	11.1	5	12.9	11	L12	12.4	2	13.1	10
L7	11.1	5	15.6	5	L13	12.2	3	10.7	15
L8	11	6	15	7	L14	12.1	4	12.3	12
L9	10.9	7	12.3	13	L15	11.8	5	19.2	1

Table 4. Cont'd

L10	10.9	7	11.2	17	L16	11.7	6	11.6	13
L14	10.8	8	15.5	6	L17	11.7	6	13.2	9
L15	10.2	11	18.2	2	L18	11.6	7	12.7	11
L16	10.4	9	18.7	1	L19	11.6	7	18.7	2
L19	10.8	8	17	3	L21	11.6	7	13.5	7
L20	9.9	12	16.8	4	L24	10.3	12	16.6	3
L21	10.3	10	15	7	L25	10.5	10	14.3	4
L22	10.9	7	14.5	8	L26	11.1	9	13.3	8
L23	10.8	8	14.1	9	-	-	-	-	-

The most important statement for H*A*'s long-term end-users is L11- *"The design, construction and final operation of hospital buildings must meet requirements such as energy, water, indoor environmental quality, and structural durability"* as can be seen in Table 4. Also, the most important statement for H*B*'s long-term end-users is L15- *"The entrance to the hospital buildings must be within walking distance of existing bus, tram, or public transport stops"*.

It has been observed that there is a noteworthy difference in the index values for the same criteria between the end users of the two hospitals. For example, L15 has an index value of 19.2 for H*B* long-term users, whereas the same criterion has an index value of 11.8 for the same type of users of H*A*. Similarly, the index value for L19 is 18.7 and 11.6 for H*B* and H*A*, respectively. A similar situation arises when the index value results of short-term users are compared. L15 has an index value of 18.2 for H*B* short-term users, while the same criterion has an index value of 10.2 for the same type of users of H*A*. When L19 is examined, it is observed that while the index value is 17 for H*B*, this value is 10.8 for the same type of users of H*A*. The comparison of index values between the end users of H*A* and H*B* reveals considerable differences for the same criteria. These discrepancies highlight potential differences in priorities between the user groups of two hospitals. Investigating the factors behind these variations may help improve hospital planning and services.

When the values presented in Table 4 are evaluated according to hospital scales, the similarities between the top three expectations of both types of users in large-scale hospitals are striking. These similar statements are L15- *"The entrance to the hospital buildings must be within walking distance of existing bus, tram, or public transport stops"*, and L19- *"Wheelchair-accessible places of respite should be provided for staff, patients, and visitors in hospital buildings"*. At this point, accessibility is the most important feature sought in large-scale hospitals for both user types. On the other hand, when the opinions of both user types in medium-sized hospitals are evaluated together, it is noteworthy that they do not have a common expectation in the top three. In Table 5, unlike Table 4, LEED v4 BD+C the main categories where user expectations are concentrated are shown instead of the most important and most preferred statements. Table 5 shows the main categories of LEED v4 BD+C in which the most important expectations of both types of end-users are grouped according to their responses for both types of hospitals.

When other categories without *IEQ* in Table 5 are examined, it is seen that the general expectations of short-term hospital end-users differ from the expectations of long-term end-users regardless of hospital scale. However, according to Table 5, the preferred category is identified as *IEQ*, while *LT* are less preferred by short-term end users. Similarly, *IEQ* is identified as the most important category for long-term end users. At this point, it is determined that the general expectations of all users prioritize the criteria related to the improvement of *IEQ*. This finding is consistent with previous studies [34-36], although a comparison of user types and hospital types was not included in those studies.

Table 5. LEED v4 BD+C main categories of short-term and long-term end-users' preferences

Short-term end-users: H*A* & H*B*		Long-term end-users: H*A* & H*B*	
Category	Statements	Category	Statements
Indoor Environmental Quality (IEQ)	L6, L7, L14, L20, L22	Indoor Environmental Quality (IEQ)	L6, L7, L14, L26
Energy and Atmosphere (EA)	L1, L2, L5, L10	Sustainable Sites (SS)	L8, L17, L19, L21
Material and Resources (MR)	L4, L9, L16	Material and Resources (MR)	L13, L16, L18, L25
Sustainable Sites (SS)	L8, L19, L21	Location and Transportation (LT)	L12, L15, L24
Water Efficiency (WE)	L3, L23	Energy and Atmosphere (EA)	L2, L11
Location and Transportation (LT)	L15		

To illustrate, occupants who use the eight certified green multipurpose buildings (with office and shops) in Ghana have been researched [34], and the results show that cleanliness, sound privacy noise level, air quality and humidity are the highest priority for improvement in terms of *IEQ*. Another study [35] focused on luminous environmental quality of hospitals with both objective and subjective approaches. According to that study, there is so much non-compliance from objective measurements. However, whereas patients and visitors are satisfied with the quantity and quality of lighting of the rooms, nursing staff are less satisfied with this. Also, this paper claims that user-oriented healthcare buildings should be designed from earlier stages of design process and especially experienced users' opinions should be evaluated. So, the research [35] supports present research's aim and results in terms of user opinion importance. On the other hand, lighting control in patient rooms has been searched according to the nurses' perception in another study [36]. The results, which show that controlling daylight and light levels is the most important lighting design issue, support this paper's preferred category, *IEQ*, in terms of lighting. Another study [22], has evaluated the effectiveness of LEED-certified healthcare settings from the perspectives of both staff and facility managers, who are long-term end-users. Those long-term end-users in LEED-certified healthcare facilities were more satisfied with building performance compared to those in non-certified facilities. Also, gold-certified healthcare buildings received higher ratings for control and comfort than silver-certified ones. All these results show the importance of end-users' perception and satisfaction. It is noteworthy that previous studies support the present study in focusing on end-user feedback within the scope of the LEED certification system, and they similarly highlight that the *IEQ* category receives the most attention.

4.1. Limitations and recommendations for future studies

Hospitals aiming for LEED certification should prioritize credits that impact patient well-being, as existing research supports the significant influence of the indoor environmental quality on both patients and hospital staff. A limitation of this study is that questionnaires were conducted in two hospitals located in the country's most populous city. The fact that Istanbul is a cosmopolitan city with a large population played a role in conducting the study there. Though the study includes two hospitals of different scales, the limitation of these two hospital samples and the resulting influence of cultural and contextual biases on generalizability must be acknowledged. The gathered responses are thus connected to the personal perceptions of individuals living within this specific cultural context. Consequently, the findings are context-dependent, providing in-depth insights applicable primarily to similar urban and hospital settings. Furthermore, recommendations for future research include proposing multi-site studies across different geographical and cultural contexts to validate the established user opposition against regional design standards and healthcare policies.

It is important to note that the observed differences in perception are seen through the lenses of user behavior, time exposure, and spatial experience. Prolonged exposure leads long-term users (e.g., staff) to develop spatial knowledge and focus on subtle, micro-level issues like maintenance, while short-term users (e.g., visitors) are often under stress, prioritizing macro-level design for initial orientation (e.g., clear signage) and being sensitive to immediate comfort. This variance reflects a fundamental shift from a holistic first impression to a critical, habitual assessment. For future research, Structural Equation Modeling (SEM) can be used to evaluate the effectiveness of LEED healthcare credits by testing complex relationships, such as Perceived Indoor Environmental Quality and Patient Satisfaction through observed indicators (e.g., survey responses and light levels). These calculations of direct and indirect influence can identify the most impactful credits, thereby validate design assumptions and inform future healthcare facility design priorities. Additionally, in the future, the results of this study can be tested and improved through an integrated approach using neuroscience-based measurement methods such as Electroencephalography (EEG), Galvanic Skin Response (GSR), Heart Rate Variability (HRV) and eye-tracking. These measurement methods could allow the comparison of conscious and unconscious responses. As a result, with this measurement methods conscious and unconscious results could be compared. Thus, differences such as those related to stress, comfort and attention between long-term and short-term end-users in hospitals could be evaluated in a quantitative way.

This study will be able to guide the future green hospital designs caring for human well-being according to both types of end-user's feedback. Furthermore, the prioritization of hospital end-users' needs could be evaluated for updating the green certification systems considering environmental sustainability, too. In the future, with a focus group the prioritized statements could be discussed with the structured expert judgement methods. Moreover, end-users of hospitals feedback could be considered as a credit input for green certification systems. On the other hand, further research is necessary to understand the reasoning behind the noteworthy differences in the needs of different types of users across hospitals of varying scales. Conducting face-to-face interviews with these hospital users in the future would be beneficial.

5. Conclusion

Sustainability, along with circular and green economy approaches, has become increasingly important and necessary. While the circular economy focuses on waste management and efficiency, the green economy emphasizes ecosystem resilience and human well-being. Achieving the UN`s Sustainable Development Goals requires addressing social, economic, and environmental issues through an interdisciplinary approach. Therefore, while focusing on circular economic issues as part of a sustainable world, it is also crucial to consider the human factor, particularly the well-being of end users.

In this study, LEED statements and categories were evaluated according to end-user opinions in medium and large-scale hospitals. Where short-term and long-term hospital user opinions were considered, it was determined that short-term hospital users prioritized the statements in the *IEQ* and *EA* categories the most. On the other hand, long-term hospital users prioritized the statements in the categories of *IEQ*, *SS* and *MR*. The results show that the LEED category most important to both types of users is *IEQ*. Although long and short-term hospital end-users prioritized criteria related to *IEQ* regardless of the scale of the hospitals, it was found that both these types of end-users have different specific expectations according to the hospital scales. End users who spend most of their time in the hospital specifically prioritized statements related to *EA* and *LT* LEED v4 BD+C categories. On the other hand, short-term end-users who use hospital buildings for treatment or visiting purposes prioritized different statements related to *EA* and *MR* categories. This has shown that sustainable hospital designs need to be examined in more detail, both from the end-user perspective and at different scales.

This study demonstrates the importance of prioritizing the health and well-being of end-users in hospital buildings, as well as considering their opinions to establish the foundation for healthy and sustainable designs. Furthermore, it examines the prioritization relationship between long-term and short-term end-users in two hospitals through a survey based on LEED v4 BD+C: Healthcare requirements. LEED categories were evaluated, and the most important statements and categories were defined from the end-users' perspective. The findings of this study are useful for drawing up specific conclusions regarding end user types and hospital scales, and it is believed that these findings can contribute to better design and management decisions. Since the facility process covers an important part of the building life cycle, end-user feedback plays a crucial role in supporting new design processes by minimizing potential problems and maximizing efficiency. This becomes a strong input for subsequent design management processes. Additionally, for maintenance activities and strategic improvements, end-user feedback is essential for evaluating ongoing processes and ensuring continuous improvement. Thus, continuous improvement enhances decision-making for environmental sustainability issues from the end-user perspective.

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Author Contributions

G. Can: Conceptualization, Methodology, Formal analysis, Investigation, Visualization, Writing - Original Draft, Writing - Review & Editing. S. Cenani: Conceptualization, Methodology, Investigation, Visualization, Writing - Original Draft, Writing - Review & Editing.

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Data Availability Statement

The authors confirm that the data supporting the findings of this study are available within the article and/or its supplementary materials.

Ethics Committee Permission

This study was conducted within the scope of bilateral agreements between Hospital A, Hospital B, and Istanbul Medipol University, School of Fine Arts, Design and Architecture. Ethical approval for this research was obtained from the Istanbul Medipol University Social Sciences Scientific Research Ethics Committee (Decision No. 169). In addition, permission to conduct interviews for the purposes of this research was obtained from all participants, who were fully informed about the aims of the study, how their responses would be used, and how they would be stored. All interviewees were anonymized.

Conflict of Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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