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Research Article

GREEN HOSPITAL CONCEPT: TRANSITION TO ENVIRONMENTALLY FRIENDLY HEALTH SERVICES

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Abstract: *This study presents a comparative assessment of the green hospital concept, a key component of environmental sustainability in healthcare, from a Turkish and European perspective. The study's unique feature is the implementation of a SWOT analysis (strengths, weaknesses, opportunities, and threats) for Türkiye and the explanatory analysis of prominent examples for Europe. The SWOT analysis conducted in Türkiye highlights the Ministry of Health's mandate for environmentally friendly building certifications for hospitals with 200 beds or more and the adoption of sustainable design elements in large-scale city hospitals as strengths. However, high investment costs, lack of standardization of sustainability criteria, and lack of awareness among healthcare professionals were identified as weaknesses. Furthermore, while increasing investment opportunities in this area within Türkiye's developing healthcare infrastructure provide advantages, economic fluctuations and uncertainties regarding the long-term stability of environmental policies were considered threats. In Europe, the green hospital approach is supported by more institutional and measurable outcomes. Notable examples include large-scale programs implemented with carbon neutrality targets under the NHS Green Plan in the UK, carbon footprint calculations conducted in university hospitals in Germany, and sustainability projects developed using a "bottom-up" method in academic hospitals in the Netherlands. Furthermore, certification systems such as BREEAM and LEED Healthcare play a critical role in disseminating green hospital standards in Europe. In conclusion, while the green hospital approach in Türkiye is still in its development, the findings of the SWOT analysis clearly highlight its strengths and obstacles. European examples offer institutional, measurable, and long-term experiences that can serve as a guide for Türkiye. This comparative approach highlights the importance of the green hospital model as a strategic healthcare policy tool that strengthens not only environmental but also economic and social sustainability.*

Keywords: *Green hospital, Eco-friendly, LEED, BREEAM, Carbon footprint*

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1. Introduction

Today, the evaluation of healthcare services within the context of sustainability is becoming increasingly important on a global scale. Hospitals are among the institutions with the highest environmental impacts due to their high energy consumption, intensive water use, waste production, and greenhouse gas emissions, necessitating the development of environmentally friendly healthcare delivery models [1]. In this context, the concept of "green hospital" stands out as an approach that represents not only energy and resource efficiency but also the holistic achievement of environmental, social, and economic sustainability. The green hospital approach encompasses multifaceted objectives such as minimizing environmental damage, creating healthy spaces for healthcare professionals and

patients, and ensuring long-term cost-effectiveness. This approach is not limited to technical infrastructure investments but is also directly linked to corporate governance policies, employee awareness, patient safety, and societal expectations [1]. Thus, the green hospital model contributes to the alignment of healthcare systems with sustainable development goals.

Healthcare systems in Europe demonstrate significant experience in institutionalizing green hospital policies. The NHS Green Plan, developed in the United Kingdom, serves as a strategic roadmap to achieve carbon neutrality in healthcare services. Carbon footprint analyses conducted in Germany have established a scientifically based framework for measuring and reducing emissions in healthcare institutions (In the Netherlands, projects developed using a "bottom-up" approach demonstrate that sustainability goals are being shaped from the bottom up, with the direct participation of healthcare professionals and local stakeholders).

In Türkiye, the green hospital approach is still in its development phase. While certain policy steps have been taken at the national level, current practices remain largely infrastructure-focused, and sustainability has not been fully integrated into institutional culture and management processes. Therefore, systematically addressing Türkiye's strengths, weaknesses, opportunities, and threats, and conducting a comparative assessment with European best practices, is critical for the process to progress more effectively.

2. Materials and Methods

2.1. Research Type

This study is based on document analysis, a qualitative research design. This is a descriptive case study conducted to explore the current state of knowledge regarding green hospitals and their practices.

2.2. Research Design

The research was designed using a case study approach. Data collected through document analysis was evaluated within the framework of a SWOT analysis.

2.3. Research Location

The research was conducted online, based on academic and scientific resources based in Türkiye. Data were collected by searching relevant content from theses, databases, academic journals, and national news portals in Türkiye. For the European section, data was collected by searching European academic databases and platforms, international academic databases, European academic journals and publications, and sources from European academic institutions and organizations.

2.4. Universe and Sample

The research population consists of all academic publications, theses, news articles, and books addressing green hospitals and their implementation in Türkiye, as well as green hospitals in Europe and other regions. The sample was selected using a purposive sampling method. A total of 38 sources (15 academic articles, 3 master's/doctoral theses, 16 current news articles, and 4 books) published between 2009, 2011, 2013, 2014, 2018-2023, and 2025 were analyzed.

2.5. Research Data Collection Tools

A data recording form, created by the researcher, was used to collect data. For each document, this form systematically recorded information such as:

- Author name,
- Year of publication,

- Type of publication (article, thesis, news, book, journal, etc.)
- Subject headings,
- Strengths/weaknesses and opportunities/threats of the Green Hospital in the healthcare field.

2.6. Data Collection

For the Türkiye section, data were searched through Ministry of Health Publications & Reports, YÖK National Thesis Center, TR Index (ULAKBİM), TÜBİTAK ULAKBİM Medical Database, DergiPark, Google Scholar PubMed, Scopus, Web of Science TürkMedline, and reliable digital news platforms in Türkiye. In the European part, EThOS (British Library, UK), DART-Europe E-theses Portal, TEL (Thèses en Ligne, France), ETH Zürich Research Collection / Swiss Doctoral Theses, NARCIS (Dutch Academic Resources), European Journal of Public Health (Oxford University Press), European Journal of Health Economics (Springer), Health Policy, European Journal of Hospital Pharmacy (BMJ Publishing), International Journal of Environmental Research and Public Health (IJERPH), Searches were provided via BMC Health Services Research (SpringerOpen), European Journal of Cardiovascular Nursing / Oncology Nursing / Other specialty journals, PubMed & Europe PMC, PubMed & Europe PMC, Scopus & Web of Science (WoS), Cochrane Library (with European Cochrane Centres), OpenAIRE, CORDIS, Horizon Europe Publications, ERIC, Springer Nature.

Due to the limited scope of the search in January, February, and March, the data was collected in 2009, 2013, 2014, 2017, 2018, 2019, 2020, 2021, 2023, and 2025 (January and March). As a result of searches using keywords such as "Green hospital," "Environmentally friendly," "LEED," "BREEAM," and "Carbon footprint," relevant documents were included in the scope of the research.

2.7. Evaluation of Research Data

The collected documents were evaluated using content analysis. Each document was analyzed within the framework of a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats). The data were divided into themes, and recurring patterns were identified and descriptive analysis was conducted.

3. Results

SWOT Analysis: The Green Hospital Concept in Türkiye is listed below;

Strengths

- Increased environmental sustainability awareness: Reducing carbon footprints and supporting energy efficiency policies [1].
- Modern healthcare infrastructure: The potential for integrating green practices such as energy savings, natural lighting, and waste management systems into newly constructed city hospitals [2].
- Long-term cost advantage: Reducing operating expenses through energy and water savings [3].
- International accreditation and prestige: The increasing global recognition of healthcare institutions thanks to green building certifications such as LEED and BREEAM [4].
- Positive effects on patient and employee health: The healing effects of natural light, air quality, green spaces, and ergonomic designs [5].

Weaknesses

- High initial investment costs: Energy-efficient appliances, renewable energy systems, and sustainable building materials require substantial initial capital [3].
- Lack of technical knowledge and expertise: Sufficient experience and expert staff are limited regarding green hospital standards in Türkiye [3].

- Lack of data: Transparent and comprehensive national health data on topics such as carbon emissions, energy consumption, and waste management are limited [6].
- Lengthy transformation process: Green transformation of existing hospitals is challenging in terms of time and cost [7].

Opportunities

- EU Green Deal and sustainability policies: As part of Türkiye's harmonization process, it can also benefit from financial incentives and grants in the field of healthcare [8].
- Renewable energy potential: The ability to use solar, wind, and geothermal resources in healthcare facilities [9].
- Increasing public awareness and demand: The rise in patient and public expectations for environmentally friendly healthcare services [9].
- Public-private partnerships: The ability to invest in green infrastructure, particularly in the city hospital model [7].
- Digital health and smart building integration: The support of the green hospital concept with IoT, artificial intelligence, and smart energy management systems [7].

Threats

- Economic fluctuations: High inflation and financial uncertainties can lead to the postponement of green investments [7].
- Legal and standard deficiencies: The green hospital concept in Türkiye has not yet been linked to clear national legislation and mandatory standards [7].
- Cultural and institutional resistance: Reluctance among hospital management and healthcare professionals to adapt to innovative environmental practices [7].
- Accelerating climate change: Rising temperatures and environmental disasters can make it difficult to sustain green practices in healthcare facilities [7].
- Outdated infrastructure problems: The physical structure of many public hospitals in Türkiye is unsuitable for green transformation [10].

4. The Concept of Green Hospitals

Like traditional buildings, hospitals worldwide are moving toward an environmentally friendly direction, influenced by the green building movement. The concept of a green hospital has gained prominence due to factors such as excessive energy and water consumption, waste generation, and increased material use. Sustainability practices have significantly contributed to the healthcare sector. These hospitals are becoming more sustainable by consuming less energy and water, reducing waste, and providing higher-quality spaces to their residents [11]. In hospitals expected to provide 24/7 healthcare services, green building practices encompass a variety of elements, including energy control, appropriate use of physical spaces, reducing material waste, managing medical and non-medical waste, greening efforts, more efficient use of energy and water, waste disposal, and environmentally friendly building designs [4].

Healthcare administrators are increasingly integrating green business and environmentally friendly practices into the design, construction, and management of healthcare facilities. Sustainable healthcare facilities primarily focus on reducing the hospital's carbon footprint and applying modern "green building" design principles to improve patient care and enhance resident comfort. This approach aims to maximize the positive impact on patients, their families, and healthcare personnel, ultimately supporting public health [12]. The design of green hospitals is an important step toward environmental sustainability. By raising environmental awareness, these hospitals contribute to the conservation of natural resources and the creation of a livable world for future generations.

5. The Importance of Green Hospitals

In the past, hospitals were small-scale structures with natural ventilation, maximum daylight, access to clean water sources, and harmony with their surroundings [13]. Today, hospitals have evolved into large complexes that can extend up to 60,000 m², where windows constitute only 10% of the building, produce approximately 5 million tons of waste annually, consume large amounts of water and energy, and provide uninterrupted, 24/7 service [14]. The enormous environmental footprint of hospitals has led them to adopt sustainability-focused solutions. Consequently, interest in environmentally friendly and nature-compatible hospital designs has increased, and the concept of "green hospitals" has gained significant ground in the healthcare sector [15]. Green hospital practices are not temporary initiatives limited to a specific project, but an ongoing process that hospitals must continually improve. By aligning this process with long-term organizational goals, healthcare facilities can develop proactive solutions to meet future needs. The green hospital approach offers several key benefits, which can be examined below:

Enhancing the value of urban living spaces

- Energy efficiency
- Water management
- Sustainable hospital design
- Waste management
- Environmentally friendly procurement processes
- Healthy and sustainable food use
- Environmentally responsible transportation systems
- Social responsibility projects
- Leadership and management approach

Each of these elements contributes to hospitals becoming more environmentally friendly and sustainable and minimizing ecological impact. They also play a significant role in improving patient health and enhancing overall societal well-being.

6. Implications of Green Architecture for the Healthcare Sector

The term "green building" is often used interchangeably with similar concepts such as "environmentally friendly building," "energy-efficient building," "sustainable building," or "high-performance building" [16]. Green buildings go beyond traditional building designs and expand the boundaries of efficiency, functionality, sustainability, and usability. The primary goal of designing these structures is to minimize negative impacts on human health and the environment [17]. The sustainability-oriented design of such buildings raises environmental awareness and encourages the efficient use of natural resources. Energy and water efficiency, waste management, and the use of environmentally friendly materials are among the key features of green buildings. The use of environmentally friendly renewable energy sources also plays an important role in reducing the carbon footprint. Green buildings are designed to minimize the negative impacts of construction on both human health and nature, ensure the efficient use of natural resources, protect the health of occupants, increase productivity, and reduce environmental damage caused by waste. These structures are constructed in environmentally friendly locations using sustainable building materials, recycling methods, waste reduction techniques, and strategies that increase energy and water efficiency while ensuring the well-being and productivity of occupants. Hospitals are among the institutions most in need of green buildings due to their operational requirements. Green hospitals not only contribute to environmental protection but also improve people's quality of life. Better indoor air quality, natural light, and views positively

impact employee health and well-being. These green building features reduce stress and illness while increasing employee productivity. Green buildings offer numerous benefits to both nature and people, as detailed below [18].

- Increasing the value of urban living spaces,
- Reducing environmental damage during construction,
- Ensuring the reuse of waste materials resulting from building demolition,
- Purifying and utilizing rainwater with green roof systems,
- Reducing the load on sewer systems by filtering rainwater,
- Encouraging the use of solar energy and supporting renewable energy sources,
- Encouraging and facilitating the use of natural light,
- Reducing heat-reflecting emissions that contribute to the greenhouse effect through green layers,
- Preventing significant energy waste,
- Saving time and financial resources through reduced maintenance,
- Improving indoor air quality with natural and healthy materials,
- Increasing the commercial value of buildings,
- Reducing carbon dioxide emissions that harm the environment through insulation techniques.

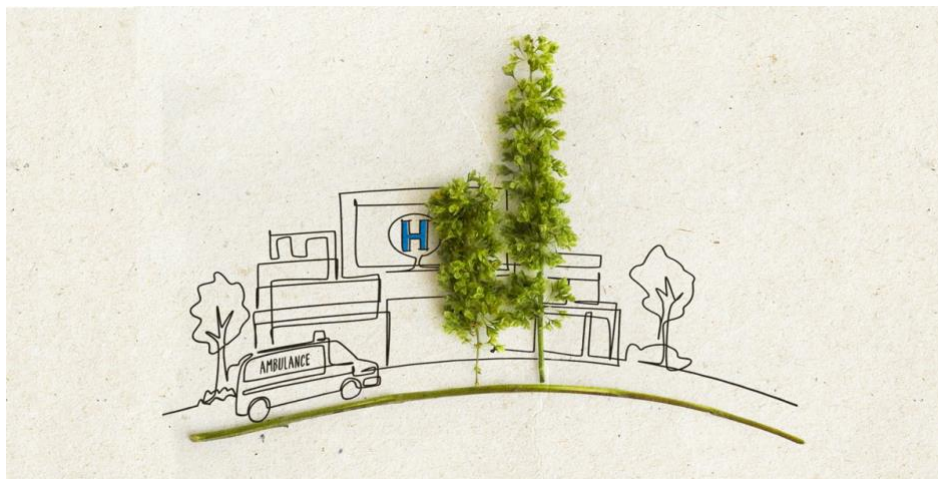


Figure 1. Green Building Concept

While hospitals provide the physical space necessary for healthcare services, their construction, maintenance, improvement activities, and materials used can also have unintended negative impacts on individuals and the environment. For example, the design and maintenance of hospital buildings can negatively impact patient health, public health, and environmental health in various ways. Numerous studies have found links between the materials used in hospitals and various health conditions. Another example is the inadequate ventilation systems in many hospitals, which contribute to poor indoor air quality and pollution. The production of polyvinyl chloride, commonly used in intravenous bags, plastic tubing, and other medical supplies, releases carcinogens that have been linked to health problems such as learning disabilities and endocrine disorders. Furthermore, the chemicals used to clean and maintain hospitals release additional toxins into the environment [19]. Green hospital buildings are recommended to mitigate these negative impacts.

7. Green Hospital Certification Processes

Increasing population, new technologies, and changes in housing demand have led to the creation of a construction sector characterized by excessive energy and resource consumption, which leads to undesirable impacts on nature. However, as sustainability has become a priority for countries, establishing a construction activity system that ensures more efficient use of resources and environmental protection has become inevitable. As a result of efforts in this area, many countries have developed building rating systems appropriate to their priorities, lifestyles, and construction techniques. These rating systems include Qatar's GSAS (Global Sustainability Assessment System), Abu Dhabi's PRS (Pearl Rating System), the US's LEED (Leadership in Energy and Environmental Design), Canada's BEPAC (Building Environmental Performance Assessment Criteria), Japan's CASBEE (Comprehensive Assessment System for Building Environmental Efficiency), China's GHEM (Green Home Assessment Guide), the US's SBAT (Sustainable Building Assessment Routine), and the UK's CPA (Comprehensive Project Assessment) certification programs [20].

Buildings are evaluated using a scoring system based on criteria such as energy efficiency, water efficiency, indoor environmental quality, and the use of environmentally friendly materials. Various certification systems have been developed in many countries for green building assessment. LEED, BREEAM, GREEN STAR, and many other green building certification systems are available. The most commonly used certification systems are detailed below.

8. LEED (Leadership in Energy and Environmental Design)

LEED is defined as a global benchmark that provides quantitative tools to directly measure a building's performance in green building design and operation [21]. The system was established in 1998 by the USGBC (United States Green Building Council) to identify and evaluate green buildings, including hospitals, within the sustainable building sector [22]. LEED is a holistic system that does not focus on a single building element but serves as a transformative tool for building hospitals that are healthy for both people and the environment [21]. Healthcare providers began implementing "LEED for Health" certification following a pilot study conducted by the USGBC and GGHC (Green Guide for Health) in 2011 [23]. Over time, different LEED certification systems have been developed for various projects. As of 2023, LEED provides a framework for green building design, construction, operation, and maintenance [24]. Moreover, it continues to be a transformative tool for building hospitals that are healthy for both people and the environment [21].

Following a 2011 pilot study conducted by the USGBC and GGHC, the "LEED for Healthcare" certification was implemented [23]. Over time, different LEED certification systems have been developed for various projects. In 2023, "LEED v4.1" was implemented as the next-generation standard for green building design, construction, operation, and performance. "LEED v4.1 BD+C: Healthcare" also includes a certification system for building design and construction. "LEED v4.1 BD+C" covers newly constructed or substantially renovated buildings, while "LEED v4.1 BD+C: Healthcare" covers healthcare institutions that provide inpatient medical care, including acute and long-term care facilities that provide 24/7 service [25]. "LEED v4.1 BD+C: Health" evaluates building performance according to various categories such as location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation and regional priorities [26].

Within the scope of "LEED v4.1 BD+C: Healthcare", a scoring system is used to evaluate building performance in each category. Each category is rated according to specified criteria, and when a certain score threshold is met, the building is eligible for certification. The scoring system consists of four levels: "Certified (40-49 points), Silver (50-59 points), Gold (60-79 points), and Platinum (80-110

points)". With LEED certification, healthcare institutions are designed and operated to consume less water, less energy, and fewer natural resources [25].



Figure 2. Leed Grade Category

9. BREEAM Certification (Building Research Establishment Environmental Assessment Method)

BREEAM is one of the most widely used green building assessment methods internationally. Developed in 1990 by the Building Research Establishment (BRE) in the United Kingdom, BREEAM is the first and longest-running building environmental assessment certification system [24]. BREEAM for Healthcare was introduced in 2008, replacing the National Health System Environmental Assessment Tool (NEAT), which was developed by BRE in 2002 to assess the environmental performance of both new and existing healthcare facilities. It was designed specifically for healthcare and has been used as a certification method ever since [27]. The adoption of BREEAM in the healthcare sector has been significantly influenced by the efforts of healthcare organizations in the United Kingdom [20].

BREEAM New Construction 2011, which also covers healthcare facilities, is regularly updated to align with building regulations, healthcare technical protocols, and best practices [27]. As of the 2018 release of BREEAM New Construction, a guide specifically for the healthcare sector has been introduced. Healthcare facilities fall into the category of non-standard building types that are assessed upon request [28]. The guideline for non-residential projects also includes special provisions for hospitals [23]



Figure 3. Breeam Evaluation Criteria

The BREEAM assessment process encompasses various categories, including governance, health and well-being, energy, water, materials and resources, land use and ecology, environment,

transportation, durability, pollution, waste, and innovation. These categories are weighted according to country or regional conditions. Within the BREEAM certification system, each category is scored against specific criteria, and when a certain threshold is exceeded, the building's certification level is determined. Certification levels are categorized as follows: "Unclassified (<30), Pass (≥ 30), Good (≥ 45), Very Good (≥ 55), Excellent (≥ 70), and Outstanding (≥ 85)" [27].

Green Star is an internationally recognized voluntary environmental certification system launched by the Green Building Council of Australia (GBCA) in 2003 [29]. The system addresses a wide range of sustainability issues while also addressing occupant health, productivity, and cost savings [24]. Whether a building is new or existing, the Green Star serves as a guide for hospitals in sustainable design and construction.

The assessment process includes categories such as management, indoor environmental quality, energy efficiency, transportation, and water. Buildings assessed using the Green Star performance certification tool receive a score from 1 to 6. Hospitals are assessed on three levels for sustainable design and construction: "4 Star (Best Practice), 5 Star (Australian Excellence), and 6 Star (World Leadership)" [29].

10. The Approach of the Ministry of Health to the Green Hospital Concept

The first step toward energy efficiency in healthcare institutions was taken with the Healthcare Energy Efficiency Project, launched in Türkiye in 2012. This project aims to optimize energy use in areas such as heating, cooling, ventilation, lighting, and medical devices by utilizing alternative energy sources.

The "Public-Private Hand in Hand Energy Efficiency" project was launched in 2012 with the cooperation of the Ministry of Health and the Ministry of Environment and Urbanization, and with the support of the Ministry of Energy and Natural Resources. Within the scope of the project, Trabzon Ahi Evren Chest, Heart and Vascular Training and Research Hospital, one of the hospitals where the data for this study was collected, was selected as a pilot healthcare facility to set an example for energy efficiency studies for public buildings. [30] Medistate Kavacık Hospital, whose work began in 2007 and became operational in 2011, is the first green hospital project implemented in Türkiye. Furthermore, the Vehbi Koç Foundation American Hospital, which is the first in Türkiye and the second in the world (existing buildings) to hold the LEED EBOM Platinum Certificate, and the Memorial Bahçelievler Hospital, which is the first in Türkiye and the third in the world (new buildings) to hold the LEED Platinum Certificate, are among the examples that can be given. According to a circular issued by the Ministry of Health in 2012, it became mandatory for existing and newly constructed hospitals with a bed capacity of 200 or more to obtain LEED certification. The international prevalence of the LEED certification system in healthcare institutions was cited as a reason for this choice. In this context, while the concept of green hospitals is relatively new in our country, the number of certifications received is quite high compared to other countries. LEED (Leadership in Energy and Environmental Design) certifications are an important criterion demonstrating the importance countries place on sustainable building design and construction. According to current data for 2023, the ranking of LEED-certified areas in countries outside the US is as follows:

Table 1. Countries with LEED certification

No	Country	Number of Projects	Certified Area (m2)
1.	China	1.563	24.553.139
2.	Canada	280	7.935.884
3.	India	248	7.236.391
4.	Türkiye	36	2.911.204
5.	Brazil	119	2.605.269
6.	Saudi Arabia	57	2.168.490
7.	Spain	169	2.001.457
8.	Italy	135	1.938.524
9.	South Korea	67	1.878.458
10.	Mexico	86	1.615.979

Source: This data is based on total gross LEED certified areas as of 2023. <https://www.gbci.org/t-rkiye-ranks-number-four-world-leed-green-building-2023>

Türkiye ranked fourth globally in 2023 with 36 LEED green building projects, certifying approximately 2.9 million gross square meters. Among these projects, the Okmeydanı Training and Research Hospital in Istanbul, with its 2 million square meters, accounts for approximately 70% of all LEED-certified areas in Türkiye. While LEED certification numbers and areas demonstrate the importance a country places on sustainability and environmentally friendly building practices, they are not directly considered indicators of development. A country's development level is often assessed using criteria such as the Human Development Index (HDI). Therefore, drawing a direct correlation between LEED certification data and a country's development rankings can be misleading.

11. Green Hospital in Europe and other Regions

Hospitals in Europe that are BREEAM/LEED certified and carry out carbon footprint reduction projects are detailed in the table below.

Table 2. Comparison of hospitals in Europe that are BREEAM/LEED certified and implement carbon footprint reduction projects

Hospital	Country	Certificate Level	Carbon Footprint Projects
Haga	Holland	BREEAM-NL Excellent	Energy recovery systems, reduction of fossil fuel use, waste heat recovery.
Midpark	Scotland	BREEAM Excellent	Low-carbon heating with biomass boilers, renewable energy integration.
New Victoria	Scotland	BREEAM Excellent	Highly insulated building elements, low carbon emission targeted design.
Álvaro Cunqueiro	Spain	BREEAM Eres	Ecosystem support, energy-efficient lighting, carbon emission reduction with therapy gardens.
Francis Crick Institute	England	BREEAM Excellent	Combined heat-power system, photovoltaic panels, low-emission transportation plan.
Great Ormond Street	England	LEED Gold	Low VOC materials, energy optimization, carbon reporting system

Table 2 Continued.

Hospital	Country	Certificate Level	Carbon Footprint Projects
Nya Karolinska Solna	Swedish	LEED Gold	100% renewable electricity, low-carbon building materials, electric vehicles for patient transport.
South Glasgow University	Swedish	LEED Gold	Smart energy management system, carbon footprint calculation and reduction targets.
PeaceHealth	USA (Washington)	LEED Silver	162 rooftop solar panels (providing 28% of annual energy), EV Charging, bioswale stormwater management <u>direct carbon reducing practices.</u>
UCF Lake Nona	USA (Florida)	LEED Gold	Energy efficiency measures with LEED performance; building based <u>energy optimization.</u>
Penn Medicine The Pavilion	USA (Pennsylvania)	LEED Gold	Large-scale energy management/ sustainable building techniques; carbon/energy performance under LEED.
San Joaquin Community	USA (California)	LEED BD+C: Healthcare v3-Silver	Energy and water savings with LEED health criteria; design compatible with regional emission reduction targets.
Providence Newberg	USA (Oregon)	Providence system	Providence is known for its LEED and carbon carbon-negative/WE ACT targets reduction programs and system-level GHG reduction strategies; Newberg is known for its local energy/efficiency practices.

The Scandinavian region (Sweden, Norway, Denmark) has some of the most advanced practices in Europe, particularly in carbon footprint measurement and reporting. Nya Karolinska Solna is one of the first hospitals built with the goal of a "carbon neutral hospital." 99.7% of the energy supplied comes from renewable sources; heat and cooling are met through geothermal energy, remote cooling, and district heat supply systems. The construction plan aims for Miljöbyggnad Gold and international LEED Gold certifications, and energy consumption has been halved compared to comparable hospitals.(31) The United Kingdom has standardized carbon footprint measurement and reduction policies in hospitals as part of its NHS target of "Net Zero NHS" by 2040.(32) These targets will become legal requirements by 2022 under the Health and Care Act 2022.(33)

12. Green Hospital Applications in Türkiye

Hospitals in Türkiye that are BREEAM/LEED certified and carry out carbon footprint reduction projects are detailed in the table below.

Table 3. Comparison of hospitals with BREEAM/LEED certification and carbon footprint reduction projects in Türkiye

Hospital	Certificate Level	Carbon Footprint Projects
Acibadem Hospital (Altunizade)	LEED Gold	Rainwater harvesting, 45% energy savings automation monitoring, recycled construction waste
Acibadem Hospital (Maslak)	LEED Gold	
Bursa City Hospital	LEED Gold	
Istanbul Prof.Dr. Suleyman Yalcin City hospital	LEED Gold	
Yozgat City Hospital	LEED Gold	
Elazig City Hospital	LEED Gold	
Adana City Hospital	LEED Gold	
Istanbul Kartal Lutfi Kirdar City Hospital	LEED Gold EDGE	
Istanbul VKV Amerikan Hospital	LEED EBOM Platinum Pioneer	business-oriented energy performance management.
Erzurum City Hospital	LEED Gold	
Gaziantep City Hospital	LEED Gold	92% recycling of construction waste, 50% energy and 42% water saving solar panels, rainwater use
Istanbul Florance Nightingale Hospital	Green Hospital Building title	
Hitit University Erol Olçok City Hospital	LEED Gold	
Istanbul Memorial Hospital (Bahcelievler)	LEED Platinum	
Istanbul Basaksehir Pine Sakura City Hospital	LEED Gold	
BHT CLINIC Istanbul Tema Hospital	LEED Gold	

Acibadem Altunizade Hospital: The project was planned with sustainability in mind from its design; it contributes positively to the carbon footprint through measures such as energy efficiency, rainwater use, and the use of recycled materials (34). Prof. Dr. Suleyman Yalcin City Hospital reduced indoor water consumption by over 40% thanks to the selection of fixtures and equipment for efficient water use. To increase energy efficiency, heating, cooling, and lighting systems were designed in accordance with ASHRAE standards, and the thermal insulation performance of the building's exterior was improved. Efficiency was prioritized in the selection of mechanical systems, and continuous energy monitoring resulted in significant savings in energy costs. As a result of all these practices, a reduction of over 42% in energy consumption was achieved (35). Kartal Lutfi Kirdar City Hospital is a prominent

project in green building practices in Türkiye, being a candidate for both LEED Gold and EDGE certification (36). VKV American Hospital is an example of implementing sustainability practices (energy performance, etc.) during the operation phase, either as a candidate or a pioneer for LEED EBOM Platinum certification (37). Gaziantep City Hospital is a campus that has implemented numerous measures that include measurable data on carbon reduction and water/energy efficiency, in addition to receiving the LEED Gold certificate (38).

13. Discussion and Conclusion

This study examined the green hospital concept in Türkiye within the framework of a SWOT analysis and presented a comparative assessment with European practices. The findings indicate that Türkiye is still developing a green hospital approach, but it holds significant potential thanks to favorable policy initiatives, academic interest, and large-scale investment projects. In the Turkish case, the Ministry of Health's mandate of international green building certifications, such as LEED, for new hospitals of 200 beds or more stands out as a strength. In this context, large-scale projects such as Basaksehir Cam and Sakura City Hospital, Gaziantep City Hospital, Bursa City Hospital, Adana City Hospital, Yozgat City Hospital, and Elazığ City Hospital, with their LEED Gold certifications, serve as examples of sustainable healthcare investments in Türkiye. Furthermore, among private sector investments, Acibadem Altunizade Hospital (LEED Gold), Memorial Bahçelievler Hospital (LEED Platinum), Acibadem Maslak Hospital (LEED Gold), and VKV American Hospital (LEED EBOM Platinum) demonstrate the applicability of environmentally friendly design in healthcare.

In these projects, rainwater harvesting systems, energy-efficient building automation, low-VOC material use, waste recycling infrastructure, and renewable energy applications contribute to reducing the carbon footprint. For example, Memorial Bahçelievler Hospital significantly reduces its annual energy consumption with solar panels and high-efficiency heating and cooling systems, while the trigeneration system used at Basaksehir Çam and Sakura City Hospitals integrates energy, heating, and cooling, reducing greenhouse gas emissions. Similarly, as part of the "Carbon Management and Energy Efficiency Projects" implemented at Acibadem Healthcare Group hospitals, carbon footprints are being reported and gradually reduced through LED lighting, smart energy measurement systems, and waste heat recovery. However, field studies have shown that the results of the Green Hospital Conformity Assessment Form, used particularly in university and training and research hospitals, are not yet fully compliant with international standards. It has been found that sustainability criteria in these institutions are mostly addressed at the physical infrastructure level, while staff awareness remains limited. Furthermore, the high initial costs associated with certification processes lead to management hesitancy, despite the long-term returns on energy efficiency investments. Similarly, the lack of standardization of green practices implemented in existing projects in operational processes, that is, the implementation of systems on a project-based basis rather than on a continuous basis, is among the most significant weaknesses of the green hospital transformation in Türkiye.

In Europe, the green hospital approach is more established and institutionally established. In the United Kingdom, as part of the NHS Green Plan (Delivering a 'Net Zero' National Health Service), carbon neutrality targets are being expanded across all hospitals, and systems like BREEAM Healthcare are being implemented as standard. Carbon footprint studies conducted at a university hospital in Germany demonstrate tangible progress in reducing emissions. Similarly, sustainability projects developed using a "bottom-up" approach are prominent in academic hospitals in the Netherlands. In particular, at institutions like Utrecht University Medical Center (UMC) and Amsterdam UMC, energy efficiency, waste reduction, food supply chain sustainability, and carbon footprint calculations are designed with the participation of employees and researchers. This allows for the implementation of continuously developed environmental solutions based on local input, rather than centralized decisions.

This approach both increases employee engagement and makes environmental sustainability goals more achievable in healthcare institutions. These examples demonstrate that green hospital practices in Europe are supported by more systematic, measurable, and long-term plans compared to those in Türkiye.

In conclusion, while the green hospital model is still in its development phase in Türkiye, European experiences offer important lessons that will inform this process. To strengthen Türkiye's strengths, cost-effectiveness analyses must be made more visible, standardized measurement and evaluation tools must be disseminated, and sustainability training for healthcare personnel must be institutionalized. Drawing on examples of good practice in Europe, Türkiye can make further progress in both energy and waste management and its carbon neutrality goals. Thus, the green hospital approach can become a strategic healthcare policy tool that supports not only environmental but also economic and social sustainability.

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