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Integrating Green Building Principles Into Family Health Centers: Scenario-Based Energy Efficiency Assessment

Yeşil Bina Prensiplerinin Aile Sağlığı Merkezlerine Entegre Edilmesi: Senaryo Tabanlı Enerji Verimliliği Değerlendirmesi

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Abstract

Aim: Many developed countries around the world are developing various policies to make their health institutions and health infrastructure sustainable. This study aims to evaluate the current energy efficiency practices in hospitals in Türkiye and investigate their applicability to family health centres (FHCs).

Material and Method: The study was conducted using a mixed and qualitative design that combined existing document analysis, comparative analysis, and scenario modelling methods. It aims to develop applicable policy recommendations for both situation assessment and future planning by evaluating data obtained from healthcare institutions operating in Türkiye.

Results: Solar energy systems (photovoltaic panels), indoor LED lighting systems, and water-saving fixtures, which are identified as the fastest and easiest to implement for FHCs in green building certification, are expected to reduce the carbon emissions of the existing 8300 FHCsby approximately 45000 tons per year, saving about 20 million kWh of energy and 1,5 million cubic meters of water annually.

Conclusion: While hospitals have the potential for transformation with more advanced systems, FHCs can contribute to environmental sustainability with simpler and lower-cost strategies. It has been determined that FHCs, based on the principles of green building criteria, are quite suitable for sustainable energy use even on a micro scale. The scenarios developed indicate that the identified practices can contribute to national environmental goals and also play an important role in raising environmental awareness in society. The successful dissemination of sustainable health policies will be possible with the active involvement of FHCs in this process.

Keywords: Green building, family health centres, sustainability

Öz

Amaç: Dünyanın birçok gelişmiş ülkesi, sağlık kurumlarını, sağlık altyapılarını sürdürülebilir hale getirmek için çeşitli politikalar geliştiriyor. Bu çalışma, Türkiye'deki hastanelerdeki mevcut enerji verimliliği uygulamalarını değerlendirmeyi ve aile sağlığı merkezlerine (ASM) uygulanabilirliğini araştırmayı amaçlamaktadır.

Gereç ve Yöntem: Çalışma, mevcut belge analizi, karşılaştırmalı analiz ve senaryo modelleme yöntemlerinin bir arada kullanıldığı karma ve nitel bir tasarımla gerçekleştirilmiştir. Türkiye'de hizmet veren sağlık kurumlarından elde edilen verilerin değerlendirilerek hem durum tespiti hem de gelecek planlaması açısından uygulanabilir politika önerileri geliştirmeyi amaçlamaktadır.

Bulgular: Yeşil bina sertifikasyonunda yer alan ve ASM'ler için en hızlı ve kolay uygulanabilir olarak belirlenen güneş enerjisi sistemleri (fotovoltaik paneller), iç mekân LED aydınlatma sistemleri, su tasarrufu sağlayan armatürlerin tercih edilmesi ile birlikte halihazırda bulunan 8.300 ASM'nin karbon emisyonlarını yılda yaklaşık 45.000 ton azaltabileceği, yıllık yaklaşık 20 milyon kWh enerji ve yıllık 1,5 milyon metreküp su tasarrufu öngörülmektedir.

Sonuç: Hastaneler daha gelişmiş sistemlerle dönüşüm potansiyeline sahipken, ASM'ler daha basit ve düşük maliyetli stratejilerle çevresel sürdürülebilirliğe katkıda bulunabilirler. ASM'lerin yeşil bina kriterleri prensibiyle, mikro ölçekte bile sürdürülebilir enerji kullanımına oldukça uygun olduğu belirlenmiştir. Senaryolaştırılarak belirlenen uygulamaların ulusal çevre hedeflerine katkıda bulunabileceğini ve ayrıca toplumda çevre bilincinin artmasında önemli bir rol oynayabileceğini göstermektedir. Sürdürülebilir sağlık politikalarının başarılı bir şekilde yayılması, ASM'lerin bu süreçte aktif bir rol almasıyla mümkün olacaktır.

Anahtar Kelimeler: Yeşil bina, aile sağlığı merkezleri, sürdürülebilirlik

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INTRODUCTION

With the increasingly evident impacts of global environmental issues and climate change around the world, a new development goal and transformation have begun.[1] The importance and feasibility of using renewable energy systems, energy-efficient building designs, and waste reduction strategies to achieve environmental sustainability goals have been recognized.[2,3] Many developed countries have developed various policies to make the infrastructure of healthcare buildings more sustainable and have started to encourage healthcare institutions in this direction.

Sustainability awareness and purpose-driven practices are increasing in Türkiye, but they are progressing below expectations. A more widespread approach and mechanisms to accelerate efforts are needed, along with practical examples.[4] Due to high energy consumption and carbon footprint compared to other public buildings, the healthcare sector has structures that need to participate in this transformation.[1] Hospitals and similar healthcare facilities are open 24 hours a day, which brings with it a significant environmental burden, from waste management to water usage.[5] Re-adapting healthcare facilities with eco-friendly and sustainable building practices will holistically protect the environment and indirectly public health.

The aim of this study is to discuss the importance of adopting environmentally friendly approaches and using sustainable energy sources in the 8.300 Family Health Centres (FHCs) operating in Türkiye, according to the Ministry of Health's 2024 data.[6] By evaluating the practices implemented in the world and in Türkiye, it aims to create a roadmap to reduce the environmental impacts of FHCs.

MATERIAL AND METHOD

In this research, the analysis of existing green hospital practices in healthcare institutions in Türkiye, the evaluation of the feasibility of these practices in FHCs, and the identification of the benefits to be gained from these practices were aimed. This study used a qualitative approach that included three parts: a careful review of national and international green building standards and health policies; a comparison of the structures of hospitals and Family Health Centers (FHCs); and creating models based on real-life data about what is possible (like national energy use reports and maps showing solar energy potential). Scenario modeling was performed using Excel-based estimations derived from published technical benchmarks (e.g., solar panel yield, water savings per fixture, etc.). Since the study is based on the construction of accessible data and universal standards using scenario modelling methods, an ethics committee application was not deemed necessary by the committee.

At the first stage, the Ministry of Health regulations, the Ministry of Energy and Natural Resources regulations, the Ministry of Environment, Urbanization and Climate Change regulations, municipal regulations and the Leadership in Energy and Environmental Design (LEED) and Building Research Establishment Environmental Assessment Method (BREAM) reports published by international certification organizations were systematically examined. The number of existing green hospitals in Türkiye, their geographical distributions, eco-friendly strategies (use of renewable energy, water efficiency, waste management, building insulation, energy monitoring systems, etc.), and certifications were determined.

In the second phase, the most commonly used structural practices of the existing green hospitals in Türkiye were compared with the structural characteristics of a typical FHC according to the Ministry of Health regulations. A comparative analysis was conducted in terms of energy consumption levels, infrastructure capacity, physical space utilization, and financial resource management . With the obtained data, it was evaluated which green building practices could be implemented in FHC.

Finally, the identified applications simulated possible green practices for FHC using the scenario modelling method. For the buildings currently in service, the environmental and energy-saving impacts of low-cost and quickly implementable interventions were estimated based on literature data. With this simulation, it was aimed to determine the potential of FHCs in terms of environmental sustainability.

RESULTS

Based on building certification criteria, a comparative analysis conducted to evaluate green building practices in hospitals and FHCs revealed that due to the intensive use of operating rooms and laboratories, hospitals have high energy consumption and require additional ventilation/ lighting systems. FHCs generally have sufficient natural lighting and ventilation due to their existing buildings, which leads to lower energy costs compared to hospitals. While hospitals aim to obtain international certifications such as LEED or BREEAM, which are more suitable for large structures, FHCs are more compatible with local or basic systems like EDGE or YeS-TR. While hospitals face challenges in green building certification processes due to complex structures and high costs, FHCs encounter limitations such as low awareness and limited local support (**Table 1**).

In the scenario modelling prepared for approximately 8.300 FHCs operating in Türkiye as of 2024, when we focus on sustainability practices, the three identified applications with low cost and high applicability are "solar energy systems (photovoltaic panels)," "LED lighting systems," and "water-saving fixtures."

Table 1. Comparative Analysis of Green Building Practices in Hospitals and Family Health Centres.

Criterion	Hospitals	Family Health Centres
Building Scale & Function	Large-scale, multifunctional, 24/7 service structures	Small-scale, basic outpatient care, usually single buildings
Energy Consumption	High – Intensive use of HVAC, ORs, laboratories	Low – Natural lighting and ventilation often sufficient
Cost of Green Transition	High – Significant investment and operational costs	Low – More affordable and accessible transformation opportunities
Certification Potential	Suitable for international standards (e.g., LEED, BREEAM)	More suited to basic or local systems (e.g., EDGE, YeS-TR)
Barriers	Technical complexity, high costs, bureaucratic procedures	Limited local support, low awareness, restricted funding
Applicable Strategies	Trigeneration, smart energy monitoring, waste heat recovery systems	Solar panels, thermal insulation, water-saving fixtures, natural air flow
Access to Incentives	Greater access to central government subsidies and public funding	Mostly reliant on local government or small-scale incentives

According to this scenario model, the installation of 3 kWp capacity rooftop photovoltaic systems for each FHC in Türkiye could generate approximately 100 million kWh of electricity annually, which is equivalent to the annual electricity consumption of about 35.000 households. It is projected that this implementation could reduce carbon emissions by approximately 45.000 tons per year. Additionally, replacing halogen or fluorescent lighting in all health centres with LED lighting systems provides an annual energy saving of approximately 20 million kWh.

Thanks to its geographical location, Türkiye has significant solar energy potential. According to the Turkish Solar Energy Potential Atlas, the annual average total sunshine duration is 2,741 hours, and the annual average total radiation value is 1,527.46 kWh/m^2. Based on the scenario, solar energy systems installed in the Southeast Anatolia region, which has the highest solar exposure, and the Black Sea region, which has the lowest solar exposure, were analysed. The Southeastern region, with approximately 1,800 kWh/m^2/year of radiation, has provided greater environmental benefits compared to the Black Sea region, which has 1,200 kWh/m^2/year of radiation. At this point, not only energy use but also the importance of location-specific planning during implementation is noteworthy (**Figure 1**).

In healthcare facilities, due to hygiene standards, water usage is the highest among public buildings. Water-saving fixtures, dual-flush toilets, and rainwater harvesting systems are the quickest and most cost-effective methods that can be implemented to reduce consumption. Gray water treatment systems are used to recycle wastewater. According to the scenario model where the use of water-saving fixtures and dual-flush toilets becomes standard in all health centres, building water usage can be reduced by approximately 35%. With this rate, an annual saving of 1.5 million cubic meters of clean water is anticipated (**Table 2**).

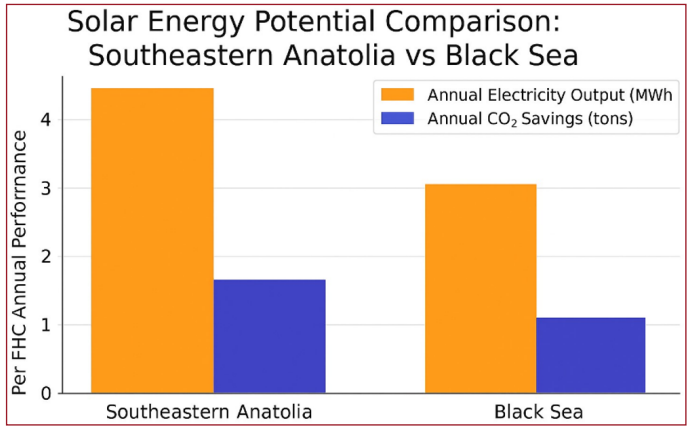

Figure 1. Solar Energy Potential Comparison.

DISCUSSION

Public buildings in Türkiye are undergoing a significant transformation through eco-friendly strategies and sustainability certifications. This transformation has begun with practices such as energy efficiency, water conservation, waste management, and building insulation. Energy efficiency and waste monitoring systems are the most rapidly implementable fundamental strategies adopted by green hospitals to ensure environmental sustainability. Although green building practices are particularly noteworthy in newly constructed health campuses, according to current data in Türkiye, 20 green hospitals have been identified, and there is no clear information on the number of hospitals in the application process.

Table 2. Quantitative Estimations for Environmental Impact of Sustainable Practices in FHCs

Parameter	Assumptions / Inputs	Calculation	Estimated Outcome
Annual Electricity Generation via Photovoltaic Systems	3 kWp per FHC Avg. output ≈ 12,000 kWh/year/FHC 8,300 FHCs	12,000 kWh × 8,300	~99.6 million kWh/year
Carbon Emission Factor	0.45 kg CO_2/kWh (Türkiye average)	99.6 million kWh × 0.45 kg CO_2/kWh	~45,000 tons CO_2/year
Electricity Savings via LED Lighting	Old lighting: 3,000 kWh/year/FHC Savings rate: ~80% 8,300 FHCs	2,400 kWh × 8,300	~20 million kWh/year
Water Savings via Efficient Fixtures	Avg. baseline: 54 m^3/month/FHC Reduction: ~35% 8,300 FHCs	54 × 12 × 0.35 × 8,300	~1.5 million m^3/year
Regional Solar Potential	Southeast Anatolia: 1,800 kWh/m^2/year Black Sea Region: 1,200 kWh/m^2/year	Higher solar yield in southeastern regions by up to 50%	Location-specific optimization possible

Nowadays, LED lighting systems, energy analysers, and automation systems are used to reduce the energy consumption of buildings. The basis of these systems is to monitor energy usage, keep it to a minimum, and increase efficiency. In some hospitals, technologies such as trigeneration systems are used to produce electricity from waste heat, thereby increasing energy efficiency. In waste management, comprehensive waste management plans are implemented with the aim of recycling service process waste, with the target of recycling 75% of the waste.

TS EN ISO 50001 Energy Management System aims to establish and continuously improve energy management systems in practices. According to the regulations published by the Ministry of Energy, green hospitals in Türkiye are expected to document their environmental sustainability through various certification systems.

To minimize energy loss, the use of high-insulation glass, which is among the criteria for green hospitals, is also recommended. Additionally, the construction chemicals used indoors should meet international standards for Volatile Organic Compounds (VOCs) to reduce environmental and health hazards. LEED certifies buildings that meet energy and environmental design criteria; the Bursa Integrated Health Campus is the only healthcare facility in Türkiye to receive LEED Gold certification. YeS-TR evaluates energy use, water and waste management, and indoor environmental quality, offering four certification levels: pass, good, very good, and national excellence. Finally, it is an honorary title of "Environmentally Friendly Hospital" awarded by the Association of Environmental Organizations, but it is not an official certification. In Istanbul, Private Türkiye Hospital has received this title.

While developed countries generally implement sustainable healthcare service structures through new buildings, in countries like Türkiye where healthcare services are provided intensively and continuously, transforming existing facilities is a more realistic and feasible approach.[2,7] FHCs are ideal pilot areas for sustainability practices due to their integration into the community and simple administrative structures.

According to the literature, green healthcare institutions play a critical role not only in environmental protection but also in raising public awareness.[3,5,8] Considering the daily patient visits and close community ties of FHCs, the environmental solutions implemented here can influence individual behaviour change and raise awareness in the surrounding households.

Some limitations are anticipated in practice. The scarcity of financial resources hinders new initiatives. Therefore, the development of incentive mechanisms will be effective. In the practices implemented in developed countries, it has been observed that tools such as public-private partnerships offered to some small healthcare institutions or green certificate awards have been effective.[9,10] In Türkiye, similar models can be expanded with energy incentives and infrastructure grants or sponsorships from municipalities.

Additionally, it is very important to raise awareness and educate FHC staff about sustainability. Healthcare professionals who internalize eco-friendly practices can help establish sustainable behaviour patterns in patient care.[4,11]

The scenario analyses in this study show that eco-friendly practices such as energy efficiency (solar panels, LED lighting), water conservation (hardware systems), and waste management can be easily implemented in FHCs with low-cost transformations and can yield significant benefits.

Agyekum and colleagues (2021) address green building practices differently for hospitals and family health centers. Hospitals are large, multifunctional facilities that operate 24/7. Despite having significant potential for sustainable transformation due to high energy consumption, complex infrastructure, and large carbon footprints, they face obstacles such as high costs and complicated technical requirements. Hospitals are encouraged to pursue international certifications such as LEED and BREEAM for corporate prestige and access to public funding.[12,13] Through comparative analysis, it is shown that the high-cost technologies used in green hospitals (for example, greywater recycling or geothermal heating systems) are not feasible for FHCs in the short term due to infrastructure and financial constraints. Therefore, this study focuses on low-cost, feasible energy and water efficiency solutions. This approach aligns better with the existing FHC infrastructure and appears more practical for sustainable health policies.

Similar to McGain & Naylor's findings (2014) on rapid payback periods for basic green strategies in primary care settings, our scenario also supports the feasibility of LED and water-saving fixtures as first-step interventions. On the other hand, health centres, which are generally single-story and have lower energy needs, are quite suitable for the implementation of simple and cost-effective sustainable solutions such as natural ventilation, insulation, solar panels, and grey water systems. However, limited support from local authorities, weak technical capacity, and low awareness hinder the widespread implementation of these practices.[14]

With this research, it was aimed to emphasize that the principle of sustainability should not be limited to large hospitals but should be spread throughout the entire healthcare system. FHCs can be the most accessible and effective connection with the community in this transformation. These practices can reduce the environmental footprint while providing economic savings, thereby helping to lessen the overall financial burden on the healthcare system.[15] Additionally, symbolically promoting the environmental identity of FHCs can raise public environmental awareness. However, mere awareness and education may not be sufficient to achieve this transformation. New regulations by policymakers to integrate environmental criteria into the accreditation of healthcare facilities would be beneficial. Although pilot implementations have started globally and locally, similar studies should be presented to policymakers since these implementations have not yet been on the agenda of FHCs.[16]

This study examines the possibilities and limitations of expanding environmental sustainability practices in FHCs in Türkiye and reveals the potential for integrating the green hospital concept into primary healthcare services. The findings have revealed that even small-scale interventions can provide significant environmental and economic benefits.

CONCLUSION

Hospitals and family health centers have different priorities and implementation challenges regarding green building practices. While hospitals have a complex structure, health centers can contribute to environmental sustainability through low-cost strategies thanks to their simpler structure. The findings of the study indicate that FHCs can contribute to environmentally sustainable development goals through the use of sustainable energy and play an important role in raising public environmental awareness. The successful dissemination of sustainable health policies will be possible with the active participation of family health centres in this process. This study expands on existing literature by providing a practical scenario-based roadmap tailored to the Turkish primary care infrastructure, which has not been previously addressed in this context. Micro-scale actions will form the foundation for macro-scale environmental transformations in healthcare services.

ETHICAL DECLARATIONS

Ethics Committee Approval: Since our research includes a scenario-based qualitative analysis, it is a research that does not require ethics committee approval.

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

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