

An Environmentally Sustainable Healthcare Unit in Greece

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ABSTRACT

For sustainable development, society needs sustainable health and medical care systems, which themselves must meet sustainability criteria in their operation. However, our health systems face urgent problems that call into question the sustainability of their services. On the one hand, the health care industry has a significant share of carbon dioxide emissions - depending on the source between 5 and 6 percent, produces large amounts of waste (sometimes hazardous) and has a very high-water consumption.

Creating an environmentally sustainable healthcare unit in Greece, involves tailoring strategies to the specific environmental challenges and opportunities present in the Greek principles. Parameters that should be examined to achieve this challenge are energy efficiency, green building design, waste management, water conservation, sustainable transportation, community engagement procurement practices and health promotion.

Healthcare units can install solar panels to generate electricity, reducing reliance on non-renewable energy sources. Additionally, optimizing HVAC systems and implementing energy-efficient lighting can further reduce energy consumption. Incorporating green building principles into hospital design and renovation projects, can enhance sustainability. This includes eco-friendly building materials, maximizing natural ventilation and daylighting, and integrating green spaces such as gardens or green roofs.

Effective waste management is crucial for environmental sustainability. Healthcare units can implement recycling programs for paper, plastic, glass, and other recyclable materials. Proper segregation and disposal of medical waste are also essential to prevent pollution and protect public health. About water conservation, healthcare units can implement water-saving measures such as installing low-flow fixtures, capturing rainwater for irrigation, and implementing greywater recycling systems. These practices help conserve water resources and reduce strain on local water supplies.

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Introduction

For the implementation of a sustainable development, the following procedures are required identification of relevant areas with significant potential for improvement in terms of sustainable management in the healthcare unit, identifying the best examples for exploiting the potential improvement, development or selection of intelligent means for effective, efficient and sustainable implementation/implementation of the application examples and development of an application-oriented design and implementation significant opportunities for improvement in the healthcare units.

Energy Efficiency

Energy efficiency plays a vital role in hospitals due to its numerous benefits and implications. By adopting energy-efficient practices, healthcare units can reduce their energy consumption and lower their utility bills. The following figure shows that the largest energy use comes from space heating (29%) and ventilation (12%) [1].

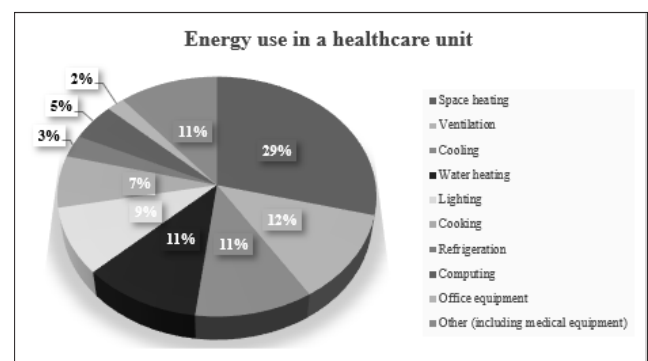


Figure 1: Current Energy Use in a Healthcare Unit

Healthcare units have a significant environmental footprint due to their high energy use. By prioritizing energy efficiency, hospitals can reduce greenhouse gas emissions, combat climate change, and create a healthier environment [2]. Energy efficiency also strengthens operational resilience by reducing dependence on external energy during disruptions [3]. These practices show a commitment to sustainability, valued by patients, staff, and the community [4]. Governments and regulatory bodies are implementing energy efficiency standards and codes to promote

sustainable practices in the healthcare sector like EU Energy Efficiency Directive (EU/2023/1791) [5,6].

Embracing energy efficiency in healthcare units, leads to innovation and technological advancement. Energy-efficient technologies, such as smart building systems, IoT applications, and renewable energy integration, are continually evolving [7]. Efficient HVAC systems help maintain proper indoor air quality, reducing the risk of air-borne contaminants and improving infection control [8]. Advanced lighting systems enhance visibility, reducing the likelihood of accidents and promoting staff and patient safety [4,7]. Some strategies that could be examples for improving energy efficiency in healthcare units in Greece are energy audits conduction, building design and retrofits, lighting optimization, equipment upgrading, installation of energy management systems, integration of renewable energy sources (RES), healthcare staff training, collaboration and partnerships with stakeholders, Building Energy Management Systems (BEMS), energy storage systems, installation of intelligent lighting systems, installation of energy efficient water systems, energy efficient medical equipment, etc. By implementing these strategies, hospitals can significantly improve their energy efficiency, reduce operating costs, enhance sustainability, and create healthier environments for patients and staff.

Green Building Design

The issue of Global Warming is rapidly evolving, so every healthcare facility requires the Green Building Concepts. The concept of Green Hospital Sustainability requires collaboration among various professionals through an Integrated Design Process [9]. By involving a multi-disciplinary team, the Integrated Design Process minimizes the negative environmental impacts at global, regional, and local levels. However, not all new designs improve comfort for patients and staff, who sometimes prefer older wards. User satisfaction is crucial, as it can accelerate patient healing and reduce hospital costs.

Table 1: Approaches for a Green Building Design

Architectural approach	Mechanical & electrical approach
Land use efficiency	Use of alternative energy
Water savings	Reduce the using of electricity power
Energy efficiency	Natural lighting
Application of the building materials used during construction	Information technology (IT)
Waste saving	
Maintenance of healthy indoor air quality	

Health and behavior, though distinct, are closely interconnected within a hospital system due to the influence of a healthy environment. Healthcare units comprise multidisciplinary professionals who must collaborate effectively, requiring specialized behavioral sciences that reflect the complex and interactive nature of health and behavior [10,11]. Hospital design plays a crucial role in integrating health and behavior. While drug development is guided by evidence-based medicine, hospital design is increasingly driven by Evidence-Based Design, which links the physical environment with patient and staff outcomes [10]. Hospitals also utilize high-tech equipment that demands both skill and intellectual rigor. The "aesthetic of the hospital"

addresses why hospitals are challenging to plan, build, operate, and maintain, emphasizing human comfort, well-designed spaces, and proper maintenance.

Additional services, service capacity, and development are key components of a hospital's strategic plan. The hospital's business strategy is a comprehensive process that involves the entire system and its subsystems. Effective planning requires strong leadership and commitment from both the hospital and other stakeholders. This process should begin with developing systems in key areas like trauma units and medical rehabilitation. Human resources development, including skill enhancement and teamwork, is essential, along with robust financial systems that ensure accurate and timely billing information [12].

Waste Management

Irrespective of how optimal a system or policy may be, an effective medical waste management program should address the following: identify activities that can be implemented by employees who are generating medical waste, determine the priority among these various activities and define the support needed at the organizational level to implement these activities.

According to the WHO, 15% of all medical waste is hazardous [13]. The issue of medical waste stems from a lack of awareness and commitment among healthcare workers, along with unclear policies on proper waste management. Inappropriate disposal and employee behavior in hospitals can lead to significant health risks and environmental pollution due to the infectious nature of the waste [14]. While the full extent of the risks from improper disposal, such as the transmission of blood-borne viruses and respiratory infections, remains underexplored, the potential health and environmental hazards are clear [15,16]. As a result, medical waste management is now considered a critical aspect of high-quality healthcare, driven by reports showing how pollutants from waste treatment threaten both ecosystems and human health [17]. To address this, medical waste management practices should encompass six key dimensions: experience, relationships, environmental factors, technology and qualifications, economic factors, and institutional capabilities. Healthcare institutions must develop comprehensive medical waste management plans that include the daily collection, processing, separation, and packaging of waste, along with regular monitoring and training programs [14,16,18].

A well-designed action plan can reduce medical waste without compromising the quality of medical services. To effectively reduce medical waste in daily operations, healthcare providers need accurate data on the volume of waste they generate. Minimizing the amount of waste requiring treatment helps lower waste management costs and enhances operational efficiency. Efficient medical waste management can be achieved through proper waste classification and sorting at the point of use. Several strategies for a resource recycling economy are reducing waste generation, reusing waste, promoting recycling, recovering energy and proper disposal [19]. These strategies emphasize the need for frontline healthcare workers to focus on reducing medical waste.

Medical waste is typically landfilled or incinerated, leading to air pollution and water contamination from landfill leaching, which raises significant environmental concerns. While hospitals recognize the importance of managing medical waste, they often delegate this responsibility to a specific department. Therefore, strategies should include clear operational standards, proper waste classification, and contingency plans for disposal issues. Additionally, all members of the organization should be informed about how medical waste

management impacts hospital operating costs. To address these challenges, comprehensive operational and management strategies are essential.

Most medical waste is classified as general waste, so it's essential to develop and implement a clear classification policy or manual. Given that medical waste management involves social, legal, and financial aspects, authorities and associations should regularly educate healthcare workers on new regulations, research, and technologies [14,20,16]. Hospitals should also offer training programs on the significance of environmental management for organizational efficiency and community safety [19]. Preventing issues in medical waste management requires effective training on the risks of improper waste classification and disposal, as well as clear operational procedures and responsibilities.

Water Conservation

Hospitals require a constant supply of high-quality, hygienic water. In areas where water supply is challenging and quality is low, ensuring adequate water becomes a significant cost for hospitals. Additionally, hospital wastewater contains numerous macro and micro pollutants, which can severely impact aquatic and terrestrial ecosystems. As part of sustainability efforts, it is now essential for hospitals to implement integrated water and wastewater management systems.

Hospitals require a significant amount of water to be used on a daily basis for various different purposes depending on the nature of operations being implemented [21]. The activities that require the most water consumption in hospitals, are washing (such as washbasins, taps, showers etc.), sanitation (used for water closets and toilet flush tanks), kitchens and cafeterias (for preparation of foods and beverages), processing (cleaning, sterilization, washing, heating, cooling, water filtration and softening) and irrigation (for ornament gardens and grass) [22].

Water consumption in hospitals varies significantly throughout the day. Specifically, water use is notably higher in the morning hours, particularly between 08:00 and 11:00, and peaks again between 16:00 and 19:00 [23]. Key factors influencing water use include the number of beds, patient count and treatment types, hospital age, water access, available utilities, corporate management policies, and the overall environmental awareness of the facility, as well as climate, cultural, and geographical factors [24].

A key strategy to reduce water consumption is to replace outdated equipment and fittings prone to leaks with new, efficient models. Installing appropriate fixtures in operation rooms during disinfection procedures can significantly conserve water. Dialysis units, for instance, use between 120 to 800 liters of water per treatment session, with much of this water dedicated to reverse osmosis systems [25]. Providing clean, sterile water in hospitals is a major challenge. Inadequate disinfection of these microorganisms can have severe consequences for healthcare institutions, especially for patients with weakened immune systems.

Sustainable Transportation

As we transition into a post-pandemic economy, healthcare industries face significant ecological and social challenges in their customer services. Hospitals are experiencing shortages of essential medical supplies, and companies are struggling to meet the surge in demand due to persistent supply chain disruptions from the pandemic.

Even as the COVID-19 pandemic recedes, healthcare systems continue to face unprecedented challenges, especially in the supply chain involving hospitals and pharmaceutical companies. Hospitals are depleting essential medical supplies rapidly, and pharmaceutical companies are struggling to meet the surge in demand due to ongoing supply chain disruptions from the pandemic [26]. The pandemic led to a significant reduction in the shelf life of medical items, with many falling below the 60% threshold [27].

The WHO reported that the COVID-19 lockdowns resulted in tens of thousands of tons of outdated medical waste, placing a significant strain on healthcare systems worldwide. The healthcare sector, while focused on saving lives and improving health, is responsible for nearly 5% of global greenhouse gas emissions (CO₂) [28]. Despite being one of the sectors most affected by the COVID-19 pandemic, CO₂ emissions have begun to rise again as demand increased and the use of alternative fuels remained limited [29].

Healthcare unit managers need to carefully plan transportation schedules, as the number of trips affects transport costs and overall expenses. Effective CO₂ management can be achieved through green technology, and managers must determine the appropriate investment to control CO₂ emissions. Further research provides practical insights, such as determining how much extra to pay drivers for deliveries to higher-risk areas, assessing how green technology performs within budget constraints and regulatory requirements and implementing pricing strategies alongside CO₂ reduction investments to enhance profitability for medical products [30].

Community Engagement Procurement Practices

The pressing reality of climate change as a healthcare crisis is more critical than ever. Weather and climate hazards impact health both directly and indirectly, increasing risks of death, noncommunicable diseases, infectious disease outbreaks, and health emergencies [31]. The World Health Organization (WHO) estimates that one in four deaths is linked to preventable environmental causes [32]. The healthcare sector faces a dual challenge: addressing these global health threats while also reducing its own contributions to climate change.

The healthcare sector is responsible for 4-5% of global carbon emissions and has a substantial impact on energy use, material demand, and hazardous waste production, which can harm air, soil, and water quality [33]. By working with suppliers to implement reduction plans, invest in greener technologies, and adhere to green standards, healthcare providers can contribute significantly to decarbonization and enhance the sector's social impact.

With the significant amounts of waste ending up in landfills and polluting our environment and oceans each year, procurement teams have a crucial role in mitigating the environmental impact of the healthcare sector [34]. For instance, many plastics take over 500 years to decompose, so choosing items with minimal or no plastic packaging can substantially reduce environmental harm [35]. Climate change presents a severe threat to human health, affecting not just the physical environment but also social and economic conditions, as well as the functioning of healthcare systems. It influences all aspects of health, from clean air, water, and soil to food systems, biodiversity, and livelihoods [36].

Less sustainable procurement practices often result in higher operational costs [37]. Enhancing the productivity of healthcare professionals is essential, and reducing burdensome tasks is key to managing operating costs. Moreover, the opportunity cost of managing less sustainable products should be considered. Legal mandates increasingly require sustainability in procurement processes, with many regions enforcing environmental laws that push organizations toward more sustainable practices.

Less sustainable procurement practices can weaken supply chains, leading to risks like supply interruptions and public backlash, with significant financial consequences [38]. Sustainable procurement is essential for maintaining employee satisfaction, as neglecting sustainability can harm morale, productivity, and staff retention [39].

To implement sustainable procurement, it's crucial to understand decision-makers' priorities, review existing sustainability targets, develop a clear roadmap, and engage stakeholders. Continuous monitoring and reporting of these practices, along with benchmarking against industry leaders, can highlight financial and reputational benefits [40]. Key international standards and frameworks include Global Reporting Initiative (GRI), ISO 14001, ISO 26000, UN Global Compact, UN Sustainable Development Goals, OECD Guidelines for Multinational Enterprises, Science Based Targets Initiative. Certifications based on remote audits may not provide the same level of assurance that a supplier is genuinely implementing the sustainability measures they claim [41].

Healthcare workers should clearly communicate their sustainability expectations during procurement. Evaluations should include both clinical evidence and feedback from a review panel, balancing technical performance with sustainability.

Health Promotion

According to data from EU Greek HealthCare, in 2017, Greece spent EUR 1,650 per capita on healthcare, which is over one-third less than the EU average. This expenditure represents 8.4% of GDP. Currently, 59% of health spending is publicly funded, while out-of-pocket expenses, at 35%, are more than double the EU average [42]. Greece faces a pressing need to rethink its healthcare financing approach. Re-evaluating the social values underpinning the healthcare system is essential for establishing a new paradigm for its sustainable development [43]. The 2030 Agenda for Sustainable Development Goals presents an opportunity for governments and the international community to reaffirm their commitment to enhancing health as a key component of development [44]. In response to climate change and associated environmental and social risks, the World Health Organization (WHO) has proposed a framework for healthcare systems. This framework encourages national healthcare systems to integrate principles, commitments, and priorities related to environmental and social policies.

Public healthcare units that apply ESG management policies, contribute to the understanding of these problems, because hospitals comply with environmental or social legislation, focus on state aid social or environmental sanctions and increase or decrease hospitals' value in relation to reducing green or labors law fines, always compared to non-compliance with environmental or social laws and legislation. Moreover, the public hospitals most often cite the following environmental, social and governance factor as the reasons they are pursuing ESG initiatives: saving money, increasing employee satisfaction and retention, managing

risk and regulatory compliance, improving facility operations and pursuing performance excellence, demonstrating and reporting the environmental, corporate social responsibility and governance issue [45].

Several public healthcare facilities in Greece have adopted sustainable practices with notable results:

- **Papageorgiou General Hospital in Thessaloniki:** Reduced electricity consumption by 37%, resulting in an annual savings of €600,000 [43].
- **Sismanoglio General Hospital:** Implemented upgrades including new boilers, improved network insulation, and solar water heaters. These changes have led to an estimated 30% reduction in energy use, equivalent to 2,280,000 kWh. Additionally, switching from oil to gas has cut energy costs by 20% [46,47].
- **General Hospital of Alexandra:** Features a pharmacy certified for quality standards, designed to be energy autonomous and eco-friendly. Sustainable healthcare presents an optimization challenge for Greek hospitals, aiming to meet environmental, social, and governance (ESG) objectives while also ensuring high-quality care, economic efficiency, and compatibility with social and environmental standards [48].

A Greek hospital committed to sustainability should integrate ESG management policies throughout all its operations and services. This approach will help promote and protect society and the environment, addressing the pressures from Greek environmental, social, and governance legislation and aligning with the healthcare market's growing demand for more environmentally and socially responsible practices [49-53].

Conclusions

In conclusion, integrating sustainability into healthcare systems is crucial for optimizing environmental, social, and governance (ESG) outcomes while enhancing economic efficiency. Greek hospitals are increasingly adopting sustainable practices, such as energy efficiency measures and waste management improvements, to benefit both the environment and operational costs. Effective community engagement and preventive care are key to promoting broader sustainability and public health. Policymakers and healthcare leaders should embrace sustainability as a strategic imperative, leveraging it to enhance resource management and support long-term development goals. By fostering a holistic approach to ESG, Greek hospitals can drive positive change, ensuring a healthier future for their communities and the environment.

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