

THE CONCEPT OF GREEN HOSPITALS AND SUSTAINABLE PRACTICES (REVIEW ARTICLE)

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Abstract

Introduction: The concept of green hospital is crucial in promoting sustainable development within health care sector. The idea is to minimize their environmental impact parallel to enhancing health and wellbeing of patients and working staff. Achieving this goal is greatly considered and outlined in the United Nations Sustainable Development Goals (SDGs) [Goal 3, which is concerned with “Ensuring a healthy life and promoting well-being at all ages”]. Paradoxically, health care sector that is considered as health protector is in the same time the main emitter of environmental pollutants that negatively affects health. Sustainability became the key priority for the whole world, governments, leaderships and health care organizations, aiming at optimizing the resources efficiently and being recognized in the community. **Aim of Work:** The aim of this review article is to provide and explore the research landscape in the field of green hospitals and highlight sustainable practices within the healthcare sector. Renewable energy integration, innovative practices, smart building management systems, benefits and challenges in implementing of sustainability practices will be explored. Green hospital certification requirements involve assessing healthcare facilities with specific environmental sustainability standards and practices that minimize resource consumption, lower carbon foot print along with maintaining high-quality patient care and staff satisfaction. In conclusion, adopting sustainability approaches and practices in health care facilities is essential for enhancing public health through reduction of environmental negative impacts, improving health outcomes, promote cost effectiveness, mitigate climatic changes, engage community and pose hospitals as leaders in health sector transformation. Green hospitals mark an inspiring step forward in how healthcare embraces sustainability.

Key words: Green Hospitals, Renewable energy, Smart hospitals, Waste management and Sustainability.

1- Introduction

As the global focus shifts towards environmental sustainability, the healthcare sector faces the challenge of balancing its life-saving mission with reducing its environmental footprint. It is said that hospitals should act for Healing Patients and the Planet (Berniak-Woźny and Rataj , 2023). As climate change continues to pose significant health risks, the role of healthcare institutions in environmental stewardship becomes increasingly crucial. Green hospitals not only reduce their environmental impact but also lead by example, promoting sustainability within their communities and the broader healthcare sector. With the challenges of climate change threatening public health significantly the importance of healthcare organizations in protecting the environment grows more vital. Hospitals that embrace eco practices not only lessen their ecological footprint but also set a positive precedent by fostering sustainability, in their communities and the wider healthcare industry (Seifert et al., 2021).

Hospital-based healthcare generates large quantities of greenhouse gas emissions. As healthcare institutions increasingly recognize their

environmental impact, the concept of “green hospitals” has gained attention worldwide (Thomson., 2015) .

Healthcare, including pharmaceuticals, is responsible for 4.4% of global greenhouse gas emissions globally. The negative impact was further intensified during the COVID-19 pandemic, primarily due to the heightened activity in the healthcare sector and the increased utilization of personal protective equipment (PPE), diagnostic tools, and vaccines for SARS-CoV-2. These factors collectively led to a significant rise in medical waste generation (Otolorin et al., 2022). Thus, the healthcare sector strives to transform itself into a sustainable one.

2- These are the three distinctive types of health care facilities which are categorized according to their performance and attitude towards the environment (Silvia et al., (2024)):

- **Sustainable healthcare buildings** are those designed to minimize the use of natural resources, promote economic growth, public health, and reduce pollution.

- **Green healthcare buildings** are adopting sustainable solutions focused on minimizing environmental

impact and promoting the health and well-being of occupants.

- **Smart healthcare buildings** are those utilizing advanced technology and building management systems for improving patient care, operational efficiency, and building performance.

The benefits of green hospitals extend beyond environmental protection. Studies have shown that green hospitals can improve patient outcomes, reduce operating costs, and enhance staff satisfaction.

Involving hospitals in sustainability program is vital in promoting a broader understanding of the interconnectedness of health and environmental sustainability.

Green hospitals, designed and operated with sustainability in mind, play a pivotal role in this endeavor. Green design strategies are frequently employed as solutions in both new and renovated architectural projects. Hospitals that prioritize sustainability implement eco friendly practices, across their operations. Green hospitals aim to reduce their ecological footprint while maintaining high-quality patient care and promoting community health. Green Building Rating Systems

(GBRS) serve as tools to assess a building's overall performance by evaluating various aspects related to its design, construction, operation, and maintenance (Abdel Rahman et al., 2021).

3- Certification:

Several initiatives for certifications, such as that is provided by the Leadership in Energy and Environmental Design (LEED), is one of the most widely recognizable certifications for sustainable buildings is administered by the U.S. Green Building Council (USGBC) for Healthcare. It provides frameworks for hospitals to adopt sustainable practices. There are certification levels as Silver, Gold, and Platinum (Bujak, (2020)). Globally, numerous hospitals have embraced the green concept, serving as models for the healthcare industry.

As of 2024, several notable developments have emerged in green hospital certification. The joint commission announced a voluntary Sustainable Healthcare Certification (SHC) program for US hospitals, providing a framework for organizations to expand their de-carbonization efforts and receive public recognition. Green hospitals

incorporate sustainable practices that optimize resources efficiently in various aspects of their operations. Green Globes Certification is administered by the Green Building Initiative (GBI). It is flexible, globally recognized certification focused on energy efficiency, resource management, and environmental impact (<https://www.jointcommission.org/>)

4- The Key Implementation Strategies involve:

4.1. Infrastructure and Design

Modern green hospitals incorporate:

- **Energy Efficiency and Renewable Energy Integration:** Hospitals are among the most energy-intensive facilities, given the need for constant operations and specialized equipment. It acts through prioritizing energy efficient designs and technologies that lower energy consumption including renewable energy sources as solar panels and wind energy that drastically minimize green gas emission associated with traditional energy use. To guarantee that buildings designed for healthcare run smoothly and maintain satisfactory indoor environmental quality (IEQ), various

components must remain operational including heating, cooling, water and lighting. The most obvious way in which hospitals can contribute to reduction in greenhouse gas emissions is to reduce energy use (Shepley and Baum, 2023). Transitioning to energy-efficient systems is vital. Implementing energy-saving technologies like Light Emitting Diode (LED) lighting, smart building systems, and renewable energy sources can significantly reduce a hospital's carbon emissions (Silva et al., 2024). Hospitals today are incorporating cutting edge energy management systems to improve efficiency and sustainability efforts in their operations.

One notable example can be seen at Lucile Packard Children's Hospital Stanford in California where they have implemented an energy storage system that produces ice during off peak hours to later use for cooling purposes when needed during the day. Thanks to this system and other ecofriendly initiatives in place at the hospital' they have managed to reduce their energy consumption by a significant 60% setting an impressive example, for similar healthcare facilities (Lucile Packard Children's Hospital reduces energy use Sustainable Stanford., 2023)

○ **Water Conservation Initiatives:** Hospitals and medical facilities instituting water-saving measures have historically seen significant operating cost and energy savings. To reduce water consumption, employees must understand how their job affects water use in their work environment and conserving water should be part of their job. The facility should locate all water using sources [bathrooms, wash sinks, hoses, dish machines, Heating Ventilation and Air Conditioning (HVAC), cooling water, etc.] and water use survey and evaluation of daily routines of staff (i.e. patient showering, cleanup, scrubbing and hand-washing) can be conducted to update current water use needs. Installing low-flow fixtures, recycling grey water, and optimizing cooling systems can help conserve water resources (<https://www.monroenc.org/>).

○ **Waste Management:** Waste management is a relatively new and potentially rewarding field of healthcare research. Hospital care produces large amounts of waste, with operating theatres contributing a large proportion. Hutchins and White (2009) declared that clinicians have an important role in reducing hospital waste and should not be discouraged by either lack of

knowledge or the threat of legal liability. Clinicians might cut the amount of waste they produce by reducing, reusing, and recycling resources. Proper segregation, recycling, and innovative waste management techniques can minimize medical waste and its environmental impact. Less than 10% of total UK National Health Services (NHS) waste is recycled. However, a comprehensive, coordinated approach to NHS waste management could have both financial and environmental benefit, primarily, reduction in surface and deep landfill, incineration, manufacturing waste, and total energy expenditure. An integrated, sustainable approach to managing hospital waste involving improved disposal systems, waste reduction, recycling, and staff training, has financial and environmental benefits.

○ **Disposal of Medical or Biohazard Waste** requires high-energy disposal processes, including proper segregation, sorting waste material and implementing innovative waste management techniques that can minimize medical waste and its negative effects, on the environment, ending with incineration (Scally, 2009).

○ **Green Spaces and Reliance on Natural Lights and Air** reduce

dependence on artificial systems spaces has been linked to faster recovery times and reduced stress levels in both patients and staff (Liu et al 2022).

4.2 .Operational Practices

4.2.a- Successful Sustainability Initiatives include:

- **Sustainable Procurement:** Choosing eco-friendly medical supplies, equipment, and food can reduce the hospital's overall environmental footprint. An example is window glass type which is a critical decision regarding energy conservation and reducing peak heating and cooling loads. Adaptive Glazing Technologies (AGTs) that modify their optical and thermal properties in response to environmental factors are suggested by the research of Sadek and Mahrous (2018).

- **Green Building Design** (sustainable building materials): Incorporating features like natural lighting, green roofs, and sustainable materials can enhance energy efficiency and create healing environments. Healthcare Buildings (HB) operate continuously around the clock and are crucial to society (Ahmad et al., 2022)

- **Continuous Assessment of Indoor Environmental Quality:**

Ensuring a healthy indoor environment is critical for patient recovery and staff well-being. Continuous assessment and management of indoor air quality (IAQ) (Ackly et al., 2024) or focusing on specific areas such as inpatient wards (Gola et al., 2019) and Operating Rooms (OR) is mandatory. This can be obtained through **Air Quality Control** using advanced filtration systems to minimize airborne pollutants as toxic materials in paints, adhesives, and furnishings with volatile organic compounds (VOCs). The research classifies the factors of indoor air in four macro-areas: outdoor air and microclimatic factors (temperature, relative humidity, air velocity, air change, etc.); management activities (management and maintenance activities, ventilation systems, HVAC, cleaning and disinfectant activities, etc.); design factors (room dimensions, furniture, finishing materials, etc.); and human presence and medical activities (users' presence, their health status, and medical activities carried out in inpatient rooms).

- **Anesthetic Gas Management:** Inhaled anesthetics are a significant contributor to health care-related greenhouse gas emissions. Anesthesiology is a carbon-intensive specialty, which contributes heavily

to global warming. Inhaled anesthetic agents as desflurane, sevoflurane, isoflurane, and halothane, which are used in general anesthesia, as well as nitrous oxide, have been estimated to be responsible for 0.01-0.10% of the total global carbon dioxide equivalent (CO₂e) emissions. Inhaled anesthetics account for 5% of acute hospital CO₂e emissions and 50% of perioperative department emissions in high-income countries. Many hospitals are now focusing on reducing the use of desflurane, an anesthetic gas with a high global warming potential. For instance, the University of Wisconsin Health system has nearly eliminated its use, resulting in a reduction of their anesthetic gas carbon footprint by about 64% (<https://associationofanaesthetists-publications.onlinelibrary.wiley.com/>)

○ **Environmental Impact of Inhalers:** The National Health Service (NHS) in the UK has been working on reducing the environmental impact of inhalers, which contribute significantly to their carbon footprint. They've been promoting the switch from metered-dose inhalers to dry powder inhalers, which could reduce carbon emissions by 58 kilotonnes annually. Novel approaches are acquired to diminish the

carbon footprint of Pressurized Metered-Dose Inhalers (pMDIs), to balance environmental goals with patient health and well-being (Pernigotti et al., 2021).

4.2.b- Innovative Practices: Hospitals worldwide are adopting innovative practices to become more environmentally friendly while maintaining high standards of patient care. The trend towards green hospitals is likely to continue as healthcare institutions recognize their role in combating climate change and promoting public health.

4.2.c- Community Engagement as sustainability in healthcare extends beyond the hospital buildings. This can be achieved by promoting Public Health involvement and staff education and training on sustainable practices to ensure the longevity of green initiatives.

4.2.d- Smart building management systems: Digital health technologies (DHTs) are advocated as tools to minimize the environmental footprint of healthcare systems.. This approach was not traditionally considered a “green” practice (Alami e alt., 2023). The World Health Organization (WHO) defines DHTs as “the field of knowledge and practice associated with the development and

use of digital technologies to improve health, including a range of smart devices, advanced computing, software for medical devices, data analytics, artificial intelligence and robotics (WHO, 2024)

The increased use of telehealth services has had positive environmental impacts and has become an integral part of healthcare, especially with the increased reliance on telemedicine and telehealth services during the COVID-19 pandemic. Telemedicine refers to the provision of healthcare services remotely by the aid of telecommunications and information technology. This might include video consultations, remote monitoring, and electronic transmission of medical records. The important role of telemedicine lies in its ability to bridge geographical barriers, improve patient access to healthcare enhancing efficient healthcare delivery systems, allowing better diagnosis, treatment and continuous remote monitoring of patients particularly in areas with limited access to medical facilities. **Digital Transformation** is digital health tools that can reduce resource consumption and improve efficiency as **Telemedicine** that decreases the need

for travel and infrastructure use and **Electronic Health Records (EHR)** to minimize paper use (Anawade et al., 2024).

5- Challenges Facing Implementations of Sustainability Procedures in Health Care Facilities:

Challenges remain in funding (the initial investment cost), technological adoption, technical expertise requirements, acquiring new environmentally friendly practices and regulatory compliance. Incorporating recent advanced building automation and Integration of artificial intelligence will be the coming step for achieving better sustainable environment. Governments, healthcare organizations, and private investors must collaborate to overcome these obstacles

(Seifert et al, 2021)

6- Benefits and Impact of Complying with Sustainability Programs:

The whole world, governments, and society in general, are becoming more aware of the effects of unsustainable practices, increasing waste, pollution, and resource depletion. Environmental compliance laws and rules aim at minimizing the negative impact activities have on the

air, water, ecosystems and other aspects of the natural world for better public image (The Benefits of Implementing a Sustainability Program in Your Organization - Simpli.com)

- **Environmental Benefits** in the form of reduced carbon footprint, lowering resource consumption, minimized waste generation, improve air quality.

- **Economic Advantages** comprises reduced operational costs, enhanced resource efficiency, improve public image and better stakeholder engagement.

Conclusion

The movement toward green hospitals represents a fundamental shift in healthcare delivery. As environmental concerns become increasingly pressing, the adoption of sustainable practices in healthcare facilities is no longer optional but a crucial component of responsible healthcare management. Green hospitals are a cornerstone of sustainable development, demonstrating that environmental issues and healthcare excellence can go hand in hand. By embracing energy efficiency, water conservation, waste management, and sustainable practices, the healthcare sector can contribute significantly to global sustain-

ability goals. By prioritizing thoughtful design, efficient use of resources, and community well-being, these facilities set an example of how we can care for the planet while providing top-notch care. Incorporating sustainable practices isn't just about helping the environment, it's about safeguarding the future of public health and improving lives for generations to come.

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