Al-Kitab Journal for Pure Sciences
ISSN: 2617-1260 (print), 2617-8141(online)
www.kjps.isnra.org

Green Hospitals for the Future of Healthcare: A Review

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Citation: Alkaabi A., Aljaradin, M., Green Hospitals for the Future of Healthcare: A Review. Al-Kitab Journal for Pure Sciences (2022); 6(2): 31-45. DOI: https://doi.org/10.32441/kjps.06.02.p4

Keyword: Green hospital, future hospital, green building, and patient-centered concepts.

Article History

Received	15 Oct. 2022
Accepted	04 Jan. 2023
Available online	07 Jan. 2023

Abstract:

Hospitals are essential for preserving and enhancing both human and environmental health. The "green hospital" concept seeks to redefine how medical facilities are constructed to preserve human life while protecting the environment. The concept of a "green hospital" and its potential benefits are discussed in this paper. It also discusses the "green hospital" concept in the United Arab Emirates as an example for future hospitals. The paper also discusses various aspects of green hospitals, such as facility design, energy efficiency, green procurement, and patient-centered concepts. Finally, the provided discussion and examples demonstrated the benefits of using the green hospital concept as a model for future hospitals, as well as the drawbacks and barriers to adopting the green hospital concept.

Keywords: Green hospital, future hospital, green building, and patient-centered concepts.

المستشفيات الخضراء لمستقبل الرعاية الصحية

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الخلاصة:

تعد المستشفيات ضرورية للحفاظ على صحة الإنسان وصحة البيئة. يسعى مفهوم المستشفى الأخضر إلى إعادة تعريف كيفية إنشاء المرافق الطبية من أجل الحفاظ على حياة الإنسان بالإضافة الى حماية البيئة. في هذا البحث تم مناقشة مفهوم المستشفى الأخضر وفوائده المحتملة. كما يناقش ايضا مفهوم المستشفى الأخضر في دولة الإمارات العربية المتحدة كمثال لمستشفيات المستقبل. يناقش البحث أيضًا جوانب مختلفة من المستشفيات الخضراء، مثل تصميم المرافق، وكفاءة الطاقة، والمشتريات الخضراء، والمفاهيم التي تركز على المريض. أخيرًا، أظهرت المناقشة والأمثلة المقدمة فوائد استخدام مفهوم المستشفى الأخضر كنموذج للمستشفيات المستقبلية، بالإضافة إلى عوائق وتحديات اعتماد مفهوم المستشفى الأخضر.

الكلمات المفتاحية: المستشفى الأخضر، المستشفى المستقبلي، المباني الخضراء، العناية المركزة للمريض .

1. Introduction:

Hospitals make a significant contribution to their communities by providing a wide range of services. Hospitals, on the other hand, operate 24/7, leaving a significant environmental footprint in many cities [1]. Hospitals have some environmental impacts, according to the US EPA (2022). Every day, hospitals generate approximately 7,000 tons of waste, which includes medical waste, hazardous waste, and municipal waste. PVC, DEHP, cleaning materials, heavy metals in electronics, insecticides, and batteries are all used in hospitals. Water is used extensively in hospitals for domestic purposes, heating/cooling, and gardening. Hospitals use massive amounts of energy in their buildings and automobile fleets, resulting in massive greenhouse gas emissions. According to Garg and Dewan (2022), healthcare facilities typically use resources such as water, energy, petroleum products, chemicals, food, building materials, gases, and so on. Because of their carbon footprint, all of these things harm the environment. Although hospitals cannot provide excellent care without the use of natural resources, hospitals can significantly reduce their carbon footprint if these resources are distributed and exploited in a simple, clever, and sustainable manner. Green building is being promoted all over the world as a means of improving the environment [2].

Green building principles are revolutionizing building practices and emerging as a growing concern about environmental degradation, increased awareness and understanding of climate change, depleting resources, rising energy costs, and growing demands for sustainable building design and construction [3]. A green hospital has no universal definition; however, it can be defined as a facility that is designed and built to use as many natural resources as possible in an efficient and environmentally friendly manner [2]. A green hospital must meet requirements for waste, environment, water, energy, hazardous material management, material properties, and efficient building layout [4]. Green building concepts not only serve to create environmentally sensitive designs, but also to protect the natural balance while meeting the required satisfaction and medical conditions [5]. Because hospitals and healthcare facilities are intended to be places of healing and rehabilitation, the influence of the environment on users is more essential than in offices or other commercial settings [6]. Ensuring universal health coverage requires that healthcare facilities operate in a safe and sustainable environment. Only when adequate water, sanitation, hygiene, and waste management are offered, as well as environmental adaptability to disasters and climate change, can patient safety be attained [7].

2. Literature Review

Health care has worldwide environmental consequences that, depending upon what indicator is used, vary between 1% and 5% of overall global effects, with certain country impacts exceeding 5% [8]. Poor management of waste, extended and excessive usage of hazardous materials, dangerous chemicals, and medical technology emitting dangerous radiation in healthcare organizations, according to research, are gradually and surely hurting the environment [9]. The healthcare industry, including hospitals, health systems, and the supply chain for medical supplies, can increase emissions over the whole lifespan of their operations [10]. Because hospitals are a significant source of pollution, the Green Hospital principles have begun to play a significant role in hospital administration. To solve some environmental issues, several hospitals have attempted to implement the "green hospital" idea [11].

2.1 Green Hospital's Significance to the Environment and Human Beings

According to Erdede et al. 2021, adopting the green building concept has numerous environmental, social, and economic benefits, such as reducing CO2 emissions, minimizing environmental damage during construction, minimizing operational expenses, enabling the use of renewable energy, enabling recycling, enabling harvested rainwater (green roofs), and

allowing for the use of ambient daylight (helps in saving energy and decreasing heating and cooling expenses) **[4, 12]**. Green roofs, for example, have the potential to improve stormwater management, reduce the urban heat island effect, increase biodiversity, and filter the air to absorb poisons and pollutants **[13]**.

A "green hospital" considers the environment to be an essential component of providing excellent care. It has characteristics such as a strategic position, efficient use of resources such as water, electricity, and air pollution, and the use of high-quality materials. It can produce more goods, maintain interior quality, and provide healthy meals and a natural environment. It promotes environmentally friendly practices, non-toxic environments, green cleaning, and trash reduction, as well as providing a therapeutic garden **[14]**.

According to Allen et al. (2015), green buildings minimize their negative effects on the environment by conserving energy and water, as well as by minimizing side effects close to the construction site. The goal of green design, on the other hand, is typically to improve people's health. Public health is significantly impacted by green buildings on two levels: directly at the individual level by providing ideal indoor environmental conditions, and indirectly at the population level by lowering energy consumption and thereby reducing harmful emissions that cause illnesses and contribute to global climate change, which is linked to a number of detrimental health effects **[15]**.

According to Danilov et al. (2020), designing healthcare facilities in accordance with green standards has a number of benefits, including quicker patient recovery (resulting in a shorter hospital stay), a reduction in sick building syndrome (SBS) for both patients and staff, and lower stress levels among hospital staff (which improves the quality of patient care) (which improves their work quality and overall hospital performance). Furthermore, a green hospital improves patient medical care while utilizing environmental resources efficiently, effectively, and sustainably **[2]**. Green hospitals had 3.6% higher overall patient satisfaction than non-green hospitals, according to Golbazi and Aktas (2020). Patients were 5.6% more likely to recommend green hospitals to others [16]. According to one study, the benefits of using a green hospital approach include reduced hospital stays by 8.5%, 15% faster healing times, a 22% reduction in the need for painkillers, and an 11% reduction in secondary infections **[17]**.

Other approaches and instruments, such as "Towards a carbon-neutral hospital," "Health Care Without Harm," and an Environmental Thermometer, have been developed specifically for the healthcare industry, and hospitals in particular. One of these strategies is illustrated by

the international nongovernmental organization (NGO) Health Care Without Harm (HCWH), which strives to transform health care globally in order to leave a smaller environmental footprint, grow into a social anchor for sustainability, and become a leader in the global movement for environmental health and justice [19].

2.2 Examples of Green Hospitals and their Advantages

Deviyanti (2022) reports that between 2016 and 2021, the RSUP Dr. Sardjito hospital was able to recycle 8.08–14.61% of 900 kg of medical waste per day and 34.35–62.2% of 9,606 kg of solid waste per month. Composting organic waste further boosts the hospital's efficiency. RSUP Dr. Sardjito will be able to save nearly $24,000 as a result in 2022. Beyond waste management, the hospital is dedicated to creating a healthier environment for guests, staff, and patients. Its green hospital initiative is carried out across all operational aspects and infrastructures, from creating environmentally friendly patient amenities like healing gardens, bike lanes, and pedestrian walkways to promoting energy efficiency [7].

The Green Hospital Scorecard (GHS) is a Canadian program that helps strengthen environmental activities, inspires behavioral modification for future conservation efforts, raises hospital awareness, and evaluates a hospital's corporate leadership, planning, and administration, as well as its energy and water saving, waste management, and pollution control efforts, according to Shi et al (2021). GHS revealed a total energy usage of 13,293,297 GJ among all participants in 2019. (83 hospitals participate in the GHS program in Canada). While the overall average energy usage intensity (EUI) for all hospitals was determined to be 2.8 GJ/m2/year, hospitals consumed a total of 8,543,242 cubic meters of water in 2018; participants' average water usage intensity (WUI) was 1.84 m3/m2/year. A total of 101,898 metric tonnes (MT) of waste were produced by hospitals, yet 39,946 MT of recyclables and other non-disposable waste were kept out of landfills. With an average waste volume of 3.15 MT/bed, participants kept around 39% of their garbage out of landfills [20].

In 2017, the Mayo Clinic in Eau Claire, Wisconsin, saved enough water to fill 50 Olympic-sized swimming pools, and renewable energy accounted for 25% of its electricity. The hospital implemented green practices by reusing 7.3 tons of plastic and 3.3 tons of surgical instruments, recycling 2.9 tons of batteries, and composting food waste [21].

One of HCWH’s achievements is the successful 15-year campaign to phase out mercury-based medical equipment and replace it with safe, affordable, and accurate substitutes. The campaign was started in 1996 at a single hospital in Boston and spread to other hospitals

around the globe. The WHO and other organizations collaborated on this international campaign, which was successful in getting language mandating the phase-out of mercury-containing thermometers and blood pressure devices by 2020 [19].

2.3 United Arab Emirates (UAE) & green hospitals

According to Todorova (2013), in the UAE, the Cleveland Clinic Abu Dhabi is a green hospital that meets Estidama's two-pearl standards. In addition, The MedHealth Medical Centre in Dubai uses a paperless method and is housed in a water and energy efficient structure. It has an irrigation system that uses condensation from air conditioners and a solar-powered hot water system that can produce 1,000 liters per day. The hospital is 50% more energy-efficient than comparable-sized structures, according to the architects, and has significant insulation to reduce heat gain while maximizing the use of natural sunlight. The building's construction method, which used roughly 30% locally made materials and 14% recycled content, adds to the facility's environmental credentials. The selection of paints and materials that don't contain a lot of volatile organic compounds—a group of chemicals, some of which are thought to be carcinogenic—was done with great care [22]. Green hospitals are definitely part of a recent sustainability initiative in the UAE. However, there is little information available in the UAE about green hospitals. Furthermore, the International Hospital Federation's 45th World Hospital Congress (WHC) was recently held in Dubai, with a focus on developing "green hospitals." During the conference, participants and decision-makers had ample opportunity to discuss potential solutions to global health concerns, particularly sustainability in healthcare. It also provides an excellent opportunity for all attendees to network, exchange knowledge, and discuss potential new areas of collaboration [23].

3. Methodology

The methodology for the study was based on a review of scholarly work in the field. The discussion centered on the main aspects of the green hospital: Green hospital facility design, green hospital energy efficiency, green hospital and patient-centered approach, green procurement in hospitals, as well as disadvantages and barriers to implementing the green hospital concept.

4. Discussion

4.1 Green Hospital Facility Design

The "green hospital" approach refers to hospitals that meet at least one of the following criteria: selecting an environmentally friendly settlement design, purchasing sustainable construction products and materials, becoming environmentally conscious during hospital construction, and remaining environmentally conscious throughout the service production process [24]. This approach is based on environmental management knowledge in a variety of areas, including waste and hazardous material management, water management, energy management, emission control systems, and innovative environmental designs.

A healthcare center's planning and design process must consider a number of factors, including energy conservation, the use of renewable energy sources, water efficiency, indoor environmental quality, the efficiency of heating and cooling systems, chemical management, waste management, environmental protection, food services, greener purchasing, greener structural materials, pharmaceutical management, and reduced transportation [2].

Green grading systems for assessing and evaluating a building's environmental performance are gaining popularity around the world. As people become more aware of the benefits of "going green," various green building grading systems have emerged. Around the world, more than six building grading systems are in use, including LEED in the United States, Canada, China, and India, Green Star in Australia, New Zealand, and South Africa, and CASBEE in Japan [25].

For example, the Leadership in Energy and Environmental Design (LEED) grading system for green buildings, which includes green healthcare facilities and structures, has grown to become the most widely recognized accreditation system in the United States [16]. The primary goals of the rating system are divided into six categories: transportation and location, sustainable site planning, water sustainability, energy and air, resources and materials, and environmental quality (indoor) [26].

Both inpatient and outpatient healthcare facilities and accredited long-term care facilities can earn the LEED for Healthcare certification. The grading scheme incorporates specialized healthcare-related tactics and is tailored to healthcare contexts [16]. Hospital administrations have collaborated with designers, architects, and construction companies to obtain the LEED certification [27].

4.2 Green hospital energy efficiency

Standard operating procedure for the majority of large western-style hospitals requires significant energy use for water heating, indoor environmental temperature and humidity controls, lighting, ventilation, and various medical procedures, with correspondingly high financial costs and greenhouse gas emissions [28]. Hospitals frequently have an energy usage intensity (EUI) that is roughly three times higher than the national average for commercial buildings [29].

Improvements in the energy economy, on the other hand, do not have to come at the expense of patient care [30]. Green designers prioritize energy conservation, particularly in ventilation and lighting. Increasing the use of natural lighting throughout the day can reduce energy costs while also improving the environment for building occupants. The importance of natural light availability and its influence on building users, particularly how it can drastically affect behaviors, has been demonstrated [6].

It may be possible to significantly reduce energy waste by taking steps like switching to compact fluorescent and light-emitting diode (LED) light bulbs, adjusting thermostats seasonally, purchasing energy-efficient items, limiting "standby" energy consumption, and upgrading buildings [31]. A program was started in 2003–2004 by Companhia Paulista de Força e Luz (CPFL), a Brazilian energy holding company, to help 101 hospitals and clinics in the state of So Paulo reduce their energy costs and greenhouse gas emissions. The simple energy-saving initiatives, which included repairing compact fluorescent lights and improving light circuits, resulted in a 25% decrease in energy consumption (and energy costs) at the 101 healthcare facilities [32].

A number of guidelines have been developed to assist in designing energy-efficient healthcare facilities. For instance, Arub 2021 presented a guide titled Energy and Resource Efficiency in Hospitals and Healthcare Facilities. The Guide offers cost-effective efficiency techniques for the design and construction of new healthcare facilities, the renovation and modernization of existing healthcare facilities, the reduction of operating costs for healthcare facilities and the technology systems that support them, and discussion of waste management and fire safety as the two most important infrastructure elements in healthcare institutions [33].

4.3 Green Procurement in Hospitals

According to CHEO (2016), green procurement is the practice of purchasing more environmentally friendly goods and services and incorporating environmental performance

measures into all phases of the procurement process, including design, purchasing, using, and disposing. Environmentally preferable goods and services have less of an impact on the environment over the course of their useful lives when compared to competing products or services performing the same function. Green purchasing eliminates negative effects on health, reduces resource consumption and waste production, and might even result in cost savings. It also encourages sustainability [34]. **Figure 1** shows the main tenets of green procurement.

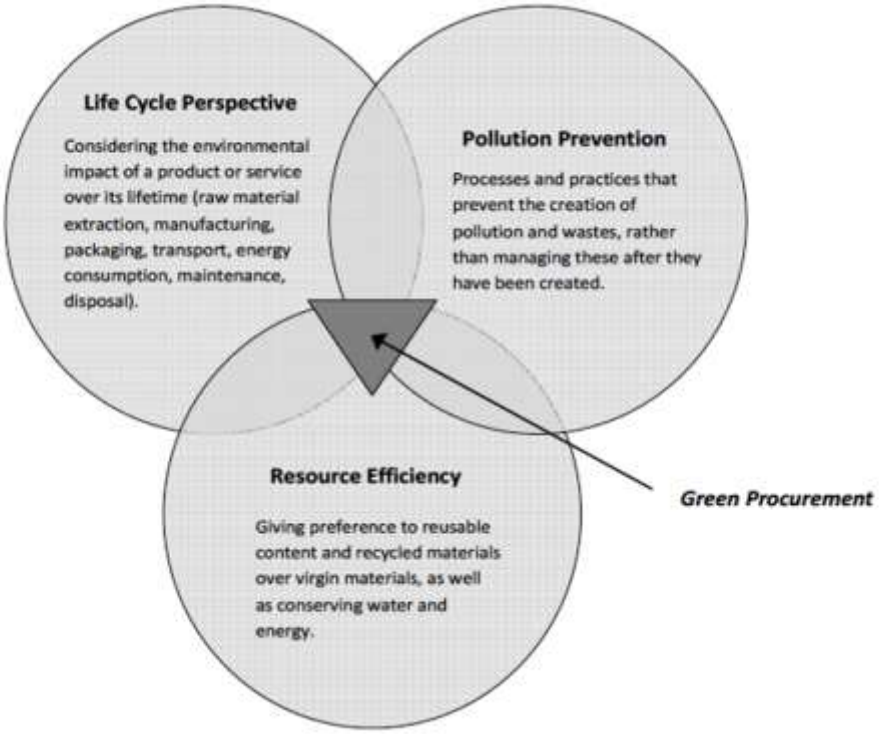

Figure 1:Green procurement principles. Adopted from [33].

In the majority of healthcare organizations, supply chain teams frequently make purchases on behalf of various departments. Healthcare product safety and quality must always come first, but procurement staff are increasingly concentrated on other aspects of a product, such as its packaging and the efficient use of water and energy [35].

Manufacturers and healthcare providers have made significant progress in adopting and integrating environmental, social, and financial sustainability throughout the industry over the past 20 years. The products' manufacturing processes and materials are being assessed by suppliers [36]. According to a study, 35% of healthcare organizations globally acknowledged switching suppliers in order to obtain more environmentally friendly products and supplies [37]. CHEO (2016) cites the following instances of green purchasing in healthcare facilities:

- Purchasing energy-efficient appliances.

- Purchasing long-lasting/durable materials and goods.
- Dealing with companies who use environmentally friendly technology and procedures.
- Applying techniques to reduce pollution or water usage.
- Purchasing materials and items that have preferable choices for recycling, remanufacturing, and/or disposal.

The United Nations Development Programme (UNDP) and Health Care Without Harm launched Sustainable Health in Procurement Project (SHiPP). The Sustainable Health Procurement program offers instructions and a plan for creating a program and governance structure that promotes sustainable health procurement **[36]**.

4.4 Green Hospital and Patient-Centered Approach

According to Shepley et al. (2009), while the first significant document to shift hospital design toward sustainable practices (i.e., Green Guide for Healthcare) was published in 2002, the Evidence-Based Design movement has been driven by the creation of patient-centered institutions that have improved patient care for the last 25 years. On a practical level, these two design philosophies do, however, largely overlap, and because they both have a goal associated with human health, their relationship is frequently synergistic. As was already mentioned, implementing a green hospital approach has numerous direct and indirect advantages for patients **[38]**.

According to Delgado et al. (2021), the interaction of technological advancement, economic market forces, rising healthcare costs, patient and staff safety, and changing governmental regulations is leading to a shift toward patient-centered care. This change is encouraging the deliberate implementation of healthy building practices that improve lighting and air quality **[39]**.

4.5 Green Hospital Drawbacks and Barriers

Adoption of green hospitals may face some challenges. There is no universal plan for green hospitals, and many countries employ a variety of models based on their geographical location and individual needs **[40]**. The Bureau of Energy Efficiency (BEE) has several green building grading systems, such as Star Rating, ECBC Compliance, Green Rating for Integrated Habitat Assessment (GRIHA), and others. These systems overlap in terms of energy efficiency, water efficiency, and waste management patterns, which may be related to geographic variations, and various companies supplying organizations must be mentioned **[41]**. Due to health and safety laws and construction regulations, hospitals are unable to adopt sustainable practices. Furthermore, hospitals must adhere to stringent infection control

procedures, which may conflict with long-term business viability [42]. Compliance with federal, state, and accrediting criteria may make it difficult to make environmentally responsible decisions [42]. The exteriors of hospital buildings can last for a long time, but interior upgrades are required every few years [42]. Green hospitals are expensive to build at first [5]. According to one study, the most pressing issues are the lack of green procurement regulations, financial assistance from senior management, government incentives for green purchases, and senior management support for green purchases [43].

5. Conclusion

Healthcare systems are critical to maintaining and improving human health, but they have environmental consequences that contribute to environmental degradation and have an impact on human health. Although the hospital's primary goal is to improve human health, it cannot be considered to exist in a bubble separate from the city. "Green Hospital" is a strategy that has emerged as an effort to improve health, which is its primary goal, as well as to address environmental issues and community needs in health issues. The green hospital concept has the potential to be a game changer for more sustainable health care. Green hospitals can be achieved through green design, energy efficiency, and green procurement. Several pieces of evidence demonstrated how the green building concept benefits both the environment and people. Even though there are obstacles, they can be overcome through innovative thinking and technology.

It is sincerely hoped that by cooperating on all levels, from the individual to the organizational, we will be able to transform the healthcare facility from a major energy consumer to an environmental advocate. More hospitals should join environmental sustainability efforts and strive for a healthy, environmentally sustainable workplace. The following are some ideas for increasing the adoption of the green hospital concept. Thinking outside the box and presenting creative, interdisciplinary design techniques that consider innovative solutions [44]. Incentives must be provided to encourage the development of innovative, sustainable healthcare facilities. When making sustainable procurement of goods and services, the entire lifecycle of healthcare delivery must be considered. This includes the manufacture and distribution of goods such as pharmaceuticals and medical devices, the actual delivery of healthcare through the efficient and sustainable procurement of services for resources such as water and energy, and the proper disposal of used products at the end of their useful lives, such as waste, packaging materials, food waste, etc. [10]. Establish an

infrastructure for action and form a committee to oversee hospital-wide sustainability initiatives by assessing baseline emissions, establishing priorities, and drafting environmental initiative regulations [33]. In the healthcare industry, the government must support, legislate, and adopt green building concepts. Through research and the examination of best practices, hospitals must constantly broaden their green initiatives in the following areas: environmentally friendly purchasing, chemical management, sustainable building and renovation, energy and water conservation, and waste management strategies, objectives, and action plans.

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