



# Sustainable Healthcare: Reducing Environmental Footprints in Medicine

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## ABSTRACT

The healthcare sector is a major contributor to environmental degradation, producing significant carbon emissions and waste. This paper examines the environmental footprint of modern medicine, emphasizing the urgent need for sustainable practices in healthcare infrastructure, waste management, and energy consumption. Barriers to achieving sustainability include resistance from stakeholders, inadequate resources, and a lack of policy formalization. Strategies for reducing healthcare's environmental impact include green building design, efficient energy use, and sustainable procurement. Case studies highlight best practices in sustainable healthcare worldwide. Ultimately, transitioning towards environmentally responsible healthcare will require systemic changes in policy, innovation, and community engagement.

**Keywords:** Sustainable healthcare, environmental footprint, medical waste, carbon emissions, green hospitals, climate change.

## INTRODUCTION

The world is growing increasingly aware of the environmental harms of human activity. Doctors, nurses, and allied, and administrative healthcare professionals are not immune; indeed, some believe there is a large gap between their perceived altruism and their environmental impact awareness. In addition, the medical industry seems inextricably tied to certain environmental harms, both through medical waste as a byproduct of their care and by contributing to coal, natural gas, and oil harms through their outsized demand as consumers. Approaches to decreasing this environmental footprint have typically included using more mindful and efficient hospital infrastructure, modalities of care, and medical equipment. A page turned left untreated in this conversation, however, is the one on which we learn what we, the general public and their advocates, need to do differently to see widespread change. Medicine and healthcare in the modern world are not environmentally sustainable. Around the world, healthcare leaders recognize the need to shrink their environmental footprints and are developing plans to make medicine more sustainable [1, 2]. Unfortunately, hospital leaders face significant barriers in making the global transition away from wasteful care – too many to buffer by regulatory actions or support from suppliers. The challenges include: 1. Inaction from stakeholders in the harm reduction cycle (i.e., pharmaceutical, equipment, and disposable supply companies, which give funding, food, commission-crafted nutrition education, and/or equipment to hospital networks and so can control or heavily steer a significant part of the healthcare system). 2. A general lack of adequate resources and support for staff engaging in change. 3. Lack of large-scale energy efficiency programs to join and leverage. 4. Impedance by the healthcare sector's traditional focus on infection control and the belief that innovations enhancing patient care and worker comfort must come at the same burden to the worker and environmental health as current models. 5. Insufficient non-toxic drug, equipment, and supply options. 6. Non-conclusive sustainability and waste research conducted on and by the hospital networks themselves. 7. Perceived absence of formalization and commitment from the government and relevant healthcare networks [3, 4].

### **Definition and Importance of Sustainable Healthcare**

Sustainable Healthcare Sustainability entails meeting the needs of the present without compromising the ability of future generations to cater to their health needs. The importance of sustainability across health systems has grown, partly to redress potential trade-offs between the pursuit of healthcare delivery models and environmental stewardship. This is based on: 1) both preventive approaches to healthcare and sustainable de-medicalization of healthy communities enhance human health while reducing ecological footprints for all pathways of material flows, and 2) a clean and healthy natural environment is an essential component of integral health. Indeed, healthcare facilities can often lead by example and help to bring about desirable, healthier, and less polluting societies. Sustainable healthcare delivery is simultaneously economically viable and also enhances social equity rather than being at odds with these imperatives. Additionally, sustainable healthcare needs progressive improvement and global spread of sustainable therapeutic innovation, and in technology-intensive care fields, it encourages reuse and waste-free surgery [5, 6]. The concept of sustainability has three interconnected dimensions, encompassing economic, social, and ecological determinants of sustainability. Meeting current healthcare needs via innovative medical treatments while preserving non-renewable resources, reducing waste, and toxicity, and buying affordable drugs, devices, and diagnostic tools for many rather than the few can lead to net improvements in health while reducing negative impacts on ecological integrity and the exploitation of future resources. It works towards "leaving no one behind" and meeting the health needs of everyone in a manner that enhances "planetary health." It also keeps operational "prudent reserves for the future equitable right of a nation to resources for future generations." To set aside such reserves can take the form of intact nature, areas, and resources with potential for future use, and the stored learning of the current age. Healthcare and the notion of sustainable healthcare encompass the full context of the institutions, practice of care, the role of public health, research, and daily health-enhancing practices. Finally, pursuing more sustainable healthcare systems, communities, and lives contributes to system resilience. For the institutional definitions and various parameters used, the dimensions described by the EcoHealth framework are typically used in health development and planning [7, 8].

### **Environmental Impact of The Healthcare Industry**

The healthcare industry has substantial environmental impacts. Healthcare facilities are generally large consumers of energy and a range of materials. Owing to the high demand for healthcare services, we are seeing an increase in the number of medical facilities and healthcare professionals. This increase also results in more resource usage, waste generation, and consequent environmental footprints. The healthcare sector contributes to 5% of the global carbon emissions. In the U.S., the healthcare sector contributes to nearly 10% of carbon emissions. The large volume of pharmaceutical drugs administered in all healthcare settings and various chemicals used in hospitals cause direct and indirect emissions [9, 10]. Surgical waste includes various types of plastics, single-use materials, and high carbon-polluting materials. A report of large hospitals indicates that 345–840 g CO<sub>2</sub>-eq is emitted per kilogram of waste. More than 160 million tonnes of healthcare waste are produced in Europe each year. The waste sector of healthcare includes two principal types of waste, namely, hazardous waste and non-hazardous waste. Both types are directly emitted to the ground, water bodies, and land, and they mix. For example, workers in this sector usually mix surgical waste with household waste. Another important environmental issue arises from the operation of healthcare facilities. Healthcare facilities are typically large facilities with heating, ventilating, and air-conditioning systems, wet and dry laboratories, procedure suites, and computing facilities. At every step, energy is used in substantial amounts, resulting in greenhouse gas emissions. Hospitals spend above 8 billion US dollars on energy every year, and they are twice as energy-intensive as other commercial buildings. Management of lighting and refrigeration represents 75% of energy usage within this setting. In addition, HVAC systems for heating and cooling represent another 19% of overall energy usage in healthcare, resulting in additional greenhouse gas emissions. The per-area material usage is high. Healthcare facilities in the United States represent about 19% of the materials usage. The healthcare industry has a large and strategic role to play in leading the world in developing and demonstrating sustainable practices for reducing the usage of, and impacts on, natural resources and protecting the environment. Healthcare providers are interested in health outcomes, and data show that health outcomes are directly linked to environmental and climatic determinants. Policies and practices in their workplaces, directly and indirectly, intersect with environmental quality, both through the facility's environmental practices and the advice that clinicians and staff provide to the general public. By ensuring that their sector is environmentally sound, healthcare providers ensure that they are "walking the walk"

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as well as “talking the talk” when they convey the global messages needed for world action. Public/private partnerships among healthcare organizations could coordinate and facilitate the rapid expansion of the green sector. There is every serious reason to believe that implementation of environmentally conscious and sustainable practices in the healthcare industry, including their products, information to patients, and operational policies, should become a major policy response of governments and relevant parties to their participation in climate change. All of these environmental measurements are or could be framed in the context of reducing the impact of the medical/healthcare industry. For example, the conservation of energy and resources in healthcare institutions will reduce the ecological footprint and greenhouse gases that are presently contributed by this industrial sector [9, 11].

### **Carbon Emissions and Waste Generation**

The majority of healthcare activities, such as the procurement of goods and energy, the continuous operation of heating, ventilation, and air conditioning systems, and the use of medical devices and pharmaceuticals, require substantial amounts of clean water, energy, and related greenhouse gas emissions, as well as produce substantial amounts of waste. Currently, healthcare buildings account for 5% of global emissions, with hospitals further contributing in high-income regions. These emissions can be grouped by their sources, those from the healthcare system, and the other sectors of the economy from which they originate, cropped from the building sector emissions. One report with a focus on the healthcare waste system found that of the estimated 12 million tonnes of waste produced globally by healthcare facilities, there is a ratio of about one tonne of waste for every bed. This waste can further be divided into two very large categories: those that are relatively benign to public health and the environment, such as cardboard and packaging, known as general waste, and those known as “biomedical waste” requiring some form of special handling, such as discarded surgical gloves and infectious waste. The balance between these two types of waste generally reflects the safety and effectiveness of healthcare provided. Healthcare’s waste footprint, including activities that create waste such as packaging associated with pharmaceutical products, is therefore substantially larger. Reducing the carbon emissions related to the healthcare system’s energy and waste in the short term is likely to have co-benefits for public health and to contribute to climate change mitigation. Gaps in data are widespread, but there are selected issues where practitioners are beginning to indicate broad consensus on appropriate action. Healthcare contributes directly to excess morbidity and mortality as a consequence of the associated emissions from energy use and waste. However, it is recognized that access to healthcare contributes directly to better health outcomes in a range of other sectors and positive social determinants, and should therefore be considered holistically for public policy in low, middle, and high-income countries alike. There is a lack of long-term data for the healthcare system about reduction requirements for both distributed and central models where the electricity supply is perfectly reliable. Efforts to improve data reporting and clinical practice include efforts led by various international organizations as the lead entity of the nine core agencies comprising the Health Care Climate Challenge, and ongoing advocacy work for climate-smart healthcare at a national level, as represented by networks focused on green and healthy hospitals. Carbon emissions, whether from energy or waste, by the healthcare system are currently putting the operational management, and thus bed capacity, of most of the world’s healthcare facilities at risk, with those in the Asia-Pacific facing risks first. Ensuring superior air quality within the healthcare facility is of such paramount concern that co-benefit analyses considering both health and climate costs are regularly conducted. The practice of sterilizing single-use surgical equipment, permitting minimal carbon emissions, has been increasingly phased out in the interests of infection prevention, favoring highly energy-intensive reprocessing efforts, though the carbon associated with these processes has not been widely quantified. While several publications have been made to support opinions and draft government policy statements, longer-term research is required to further verify results and draw meaningful conclusions. Unless sound regulations and best practice guidelines, which include better models for the end of product life, are developed swiftly, the importance of those emissions relevant to end customers will overshadow a much-needed transition to more sustainable, climate-smart practices [12, 13].

### **Strategies For Reducing Environmental Footprints**

Given that the environmental footprints of healthcare organizations vary depending on their location, facility type, and operational capacity, there are general strategies most facilities can follow to reduce their environmental footprints. One key area of intervention is technology upgrades, including the adoption of energy-efficient lighting, solar heating systems, and heating, ventilation, and air conditioning systems. Companies can also adopt active design structures for facilities, including proper levels of

insulation, tall windows, and strategic window placements to reduce energy consumption. Techniques for greener healthcare operations include the addition of plants around facilities for improved indoor air quality and reducing emissions from heating and cooling systems. In terms of transportation, companies can invest in more fuel-efficient models of vehicles, limit the number of vehicles on the facility campus, and encourage employee bike sharing and walking. Technological tactics include reporting total energy consumption and identifying how much comes from green power as well as adopting sustainable supply chain management [14, 15]. Educational and social strategies that involve staff members in environmental actions or issue-focused campaigns also play an important role in organizational environmental sustainability by developing a facility-wide culture of sustainability. These include regular staff training to inform employees of environmental goals and provide executors with realistic timelines on when an organization expects compliance with these new behavioral norms. Additionally, educational initiatives should aim to motivate employees to adopt these behaviors as global citizens and not just as hospital staff and should include spaces for feedback or modified staff input in making the campaign successful. Moreover, corporations should be working on legal and government lobbying programs since nationwide bans and formal sanctions on certain actions may discourage businesses from breaking environmental rules. This includes fines for using conventionally produced energy sources, spot rewards or tax credits for sustainable activities, or implementation of minimum energy-efficient vehicles. Finally, a cost-benefit analysis must be conducted to evaluate the impact of the project to weigh the initial cash outlay against the long-term savings. A return on investment is given at this stage and, once confirmed, initiatives are implemented following the use of joint financial options [16, 17].

### **Green Building Design in Healthcare Facilities**

Principle Six of the Sustainability Roadmap for Hospitals highlights why hospital design and construction need to be undertaken with measures in place for environmental sustainability. Green building is defined as the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life cycle, from siting to design, construction, operation, maintenance, renovation, and deconstruction. There are six basic principles common to any craft-generated type of constructed space that is sustainable, involving: the use of a small space, sustainability of the landscape, building envelope, building footprint, use of footprint infrastructure, and urban form. These principles are underpinned by the understanding, application, management, and conservation of known and useful principles of science in concert with the principles drawn from inspired leadcraft [18, 19]. The use of sustainable building design is germane for healthcare facilities. Aesthetically, healthcare facilities can provide a reassuring sense of solace, hope, and safety to patients. Functionally, direct links between the healing process and the immediate physical environment can no longer be disregarded. Sustainable architectural practices in the built environment seek ecological, socioeconomic, cultural, and individual harmony between human beings and the natural environment. Healthcare building design encompasses a plethora of sustainable elements, including energy efficiency, the optimal life cycle cost, adaptability to changing medical technology, durable materials, optimal environmental quality, waste management logistics, disease and infection control measures, and the use of protection and security measures. The main aim of these practices is to reduce the severity of a building's environmental footprints from a life-cycle perspective. This includes the concept of reducing adverse impacts on physical and human health, the natural environment, and the social fabric of the community. They engender reduced hospital operating costs through reductions in energy, potable water use, and other corporate savings [20, 21]. Sustainable architectural design practices concurrently take a preventative role in reducing exacerbations of injury and illness. Patients and other end-users are provided safe indoor environments that emit low levels of toxins, possess an indoor environment as close to that of the natural world as possible, ensure protection from the elements, encourage natural healing mechanisms and reduce hospital-induced illness. The incorporation of green building design practices into healthcare facilities has now been examined from real-world case studies, attesting to the window of expectations that are used in each effort to provide many benefits, the expected return on investment, and short gestation periods. The transition of the financial investment foundation to sustainability is underway throughout Australia but is yet to impact significantly on the financial sector of the Australian economy. It is well past time for the leaders in the Australian healthcare sector to lead the change, instead of following in the footsteps of other economic sectors. Efforts toward sustainable practices in the design of healthcare facilities can profoundly impact the environmental footprint of all manner of healthcare services. Health professionals are duty-bound to prevent harm and sustain the health of individuals, communities, and the population as

a whole. The healthcare sector needs to take the initiative for the implementation of sustainable building design systems that can significantly reduce operations upon human health as a noble obligation and as part of its ethos. Currently, healthcare design alone represents 1% of the Australian economy [22, 23].

#### **Case Studies and Best Practices**

In this collection of materials, some case studies exemplify strategies implemented for sustainability by the delivery system. To elaborate on the business case, strategy, innovation, business solution, and implementation of this integration of sustainable good practices, after presenting their topical title, this paper represents the organization and their prior fiscal year operating results and community health promotion and health care services which received certification in 2021. Southern Arizona is home to a great ADA, Native American, and Latino community. They serve rural and urban patients, veterans, and military families. This highlights annual measures of sustainable change projects in health care internationally. Establishing the collection of best practice cases, this collection will highlight change projects internationally while providing a tool for facilitating the transfer of best practices. The materials also include a business case for integrating environment and sustainability into healthcare strategies and case studies of individual hospitals that received awards [24]. This paper captures some of the dimensions of this spending that contribute to the partnerships currently being used by healthcare institutions with best practices in supplier relationships that are generally beneficial to the community for which a non-profit healthcare provider of safe, high-quality care will be accountable. Beyond best practice partnerships for the patient and family-focused high-reliability care strategic suppliers, other main case studies in best practices for sustainable spending document the following: a) To be included in the pharmaceutical cost base for increasing the supply chain that meets the requirements, including traffic light preferences for energy-efficient vehicles; b) To include corporations that show diversity through recognition as corporations of excellence, and to expand procurement into development or small or expediting vendors that currently exceed 15% of contract percentages; c) Over five years, the upgrade to the extensive redoing goal to make these centers' supply chain more sustainable, and green award winners and individual supplier anchor spots have added five best practices to date [25].

#### **Future Directions**

With increasing attention now being paid to health, healthcare, and the environment, it is acceptable to argue that healthcare ought to become more sustainable. This review presents evidence to suggest that medicine is making progress towards this goal. However, there is still much work to be done before this potential can be realized. The primary barrier has been the short-term focus on cost reduction shared by stakeholders across the healthcare spectrum, with a long-term view of environmental sustainability often disregarded. There is a significant opportunity to internalize these external costs through prevention and integration of environmental objectives into the health service [26]. There is a clear need for more research into how these concepts can be tested and implemented. This will require innovations in technology, education, and policy. At an organizational level, attempts at sustainability strategies should focus on innovation, collaborative strategies, and a proactive, preventative approach, and seek to reflect and engage with local communities. An integrated organizational policy may be an effective vehicle by which this can be achieved. In the future, research into the effectiveness of different strategies for achieving sustainability could provide the drivers toward long-term preventive approaches that this systematic review has shown to be the only viable option in health and medicine, to achieve genuine progress toward sustainability. Furthermore, the benefits of an engaged, healthy, optimistic community would ultimately bring economic, social, and health benefits, with studies showing that many interventions will direct savings. In our view, healthcare needs to rethink the focus of activity away from sickness, cost, and short-term care to prevention, environmental impact, and long-term care. Ongoing review, planning, and collaboration are necessary for further research into the effectiveness of such strategies [27].

#### **CONCLUSION**

Sustainable healthcare is no longer optional; it is a necessity for the future of both medicine and the planet. While progress has been made in reducing environmental harm through green infrastructure, waste reduction, and efficient energy use, significant challenges remain. The healthcare industry must adopt long-term strategies that integrate sustainability into daily operations, policy frameworks, and supply chains. Future research and innovation should focus on sustainable technologies, preventive care models, and global collaboration. By prioritizing sustainability, the healthcare sector can lead the way in mitigating climate change while improving patient care and community health.

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