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Critical Analysis of Healthcare Sustainability in Environmental Impact, Resource Management, and Ethical Considerations

Albanadria Shwayhit Luwayfi Alsharari[1], Sara Salamh Atwi[2], Zafaran Khaled Salem Abuaeaaq[3], Fahad Saad Kurdi Alanazi[4], Faisal Khalid Mohammed Alanazi[5], Mohsen Yahya Mohsen Aldoshan[6], Sara Blaal S Alyami[7], Mona Ayed Alazmi[8], Hani Mukhlef Khalaf Al-Anzi[9], Salem Bader Alabas[10], Abdulrahman Hussain Rabia Allah Alsharif[11]

Abstract

For people, healthcare systems are crucial; the flip side is that these same systems are highly unsustainable in terms of the waste they produce, their carbon footprint, and the resources they consume. Health care sustainability involves consideration of the environmental impact, resource use, as well as ethical issues. This paper evaluates these three perspectives: as a driver of environmental degeneration through climate change, its contribution towards sustainability, and equity concerning environmental justice. Information presented and case descriptions and discussion focus on obstacles and best practices to incorporate sustainability into healthcare organizations.

Keywords: *Healthcare Sustainability, Environmental Impact, Resource Management, Ethical Considerations, Carbon Footprint, Waste Management, Health Equity.*

Introduction

The healthcare industry, as a sector that has a critical role in improving the quality of life and protection of the population's health, is one of the main producers of environmental pollution. Hospitals and most healthcare centers produce large quantities of medical waste, use large quantities of energy, and release sizable GHAs. The negative impacts of these factors are increased environmental degradation, climate change, and depletion of resources. These requirements call for sustainable health care. Applying the principles of delivering qualitative care while being environmentally friendly is a global concern because the health sector contributes roughly 5-10% of the carbon footprint in developed countries (WHO, 2022).

Among those environmental concerns, the most critical areas can be highlighted as the following: The generation of electricity to power the heating, ventilation, lighting, and other diagnostic equipment that are used in healthcare facilities such as CT scanners and MRI machines. Staple technologies, as crucial as they are in the delivery of patient care, account for a big portion of the total energy use and CO2 output. Also, anticipating discard after a singular use of medical plastics, syringes, or PPEs enhances the generation of non-degradable waste. Lack of proper disposal increases the impact on the environment, especially in developing countries where waste disposal facilities are nearly absent (Pinzone et al., 2016). Solving these

[1] Ministry of Health, Saudi Arabia, Email: Albanadria@moh.gov.sa
[2] Ministry of Health, Saudi Arabia, Email: ssatwi@moh.ov.sa
[3] Ministry of Health, Saudi Arabia, Email: Zabuaeaaq@moh.gov.sa
[4] Ministry of Health, Saudi Arabia, Email: falanazi101@moh.gov.sa
[5] Ministry of Health, Saudi Arabia, Email: fakalanazi@moh.gov.sa
[6] Ministry of Health, Saudi Arabia, Email: mmoshawat@moh.gov.sa
[7] Ministry of Health, Saudi Arabia, Email: Sabealyami@moh.gov.sa
[8] Ministry of Health, Saudi Arabia, Email: moaalazmi@moh.gov.sa
[9] Ministry of Health, Saudi Arabia, Email: halanazi7@moh.gov.sa
[10] Ministry of Health, Saudi Arabia, Email: salabas@moh.gov.sa
[11] Ministry of Health, Saudi Arabia, Email: abalsharif@moh.gov.sa

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issues calls for creativity in order to enhance the use of resources, diminish carbon footprints, and ensure sustainability in healthcare facilities.

This Paper Aims To

- Review the environmental stewardship by studying the healthcare energy intensity, healthcare waste, and GHG emissions. It will evaluate the impact that healthcare has on the environment and further discuss the available sustainable developments that seek to reduce the impact.

- Analyze the responsibilities of resource management in managing the sustainability features of the healthcare facility. These are items such as efficient structures, going green mainly by using power from renewable sources, resource recycling, and ways of dealing with health facility waste. The paper will demonstrate key successes in resource optimization through the analysis of case studies as well as available data.

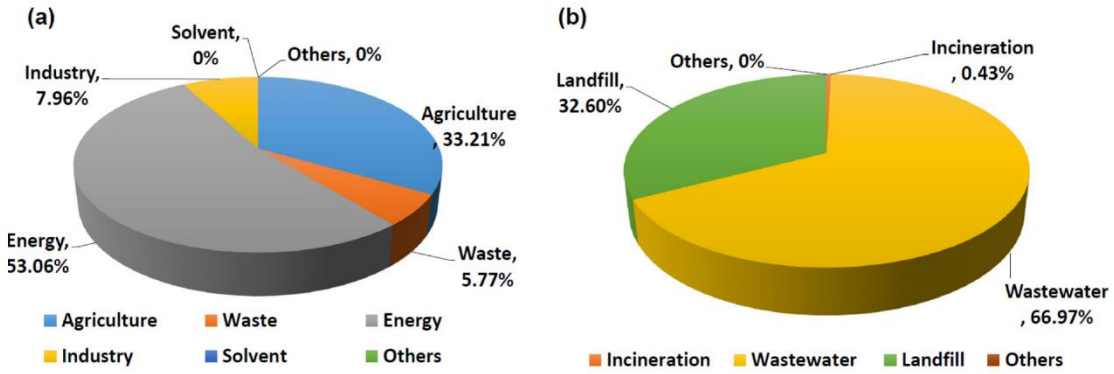
- Discuss potential/suggested ethical issues when considering sustainable systems in developing states' healthcare. Issues like environmental justice, in that sustainability should be done at the expense of sorry patients' specific concerns and disparities where vulnerable groups are always on the receiving end of the environmental buck passed off.

Literature Review

Environmental Impact of Healthcare Systems

The environmental footprint of healthcare systems has raised global concern, given that healthcare facilities account for about 5-10% of national carbon emissions in developed countries (WHO, 2022). These emissions are mainly generated by energy usage, operation of medical equipment, means of transportation, and production of medical wastes. Hospitals and other related healthcare facilities are some of the most consuming facilities that demand high energy input towards their lighting, heating, cooling, and air conditioning, as well as powering their diagnostic equipment, including computerized tomography (CT) and magnetic resonance imaging (MRI). For instance, a routine MRI machine uses up to 30 kWh per hour and expels greenhouse gas (GHG) emissions in the process in the event that it is run by renewable energy (Healthcare Without Harm, 2021).

Globally, single-use medical supplies deepen the layer of environmental cost in healthcare. Syringes, PPE, gloves, and any other disposable instruments, as well as other equipment of the healthcare sector, are indispensable to patient safety as well as controlling infections but are also contributing to the pile of no biodegradable waste. Single-use plastics were found to occupy 30% of all hospital waste, and these contribute to long-term environmental damage through landfilling or littering the aquatic environment (Nguyen et al., 2021). The COVID-19 pandemic has also aggravated this problem since, amid the global demand for PPE and disposable medicine items, millions of tons of additional plastic have been created.



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Breakdown of Wastes by Activity to Total Carbon Footprint (Temporary data: Graph representing the amount of GHG emissions based on energy usage, utilization of medical equipment, and waste production(Stahl et al., 2020).).

However, constrained medical waste transportation and disposal escalate the healthcare sector's consequences. Dangerous, toxic chemicals, pharmaceuticals, and other radioactive substances demand a separate way of disposing of them to reduce the impact of contamination. They also found that in cases where waste is not well sorted, chemicals effuse into the water solutions of the soil—an issue that would have significant impacts on human health as well as the environment (WHO, 2020). There are likely to be more challenges in developing countries where there are scarce facilities for handling and treatment of refuse, where such waste is sometimes improperly burnt or dumped.

Measures that have been taken in the healthcare organization to reduce its effects on the environment include the adoption of green sources of energy and efficient energy infrastructure, among others. There is "Healthcare Without Harm," a program that calls for healthcare construction that has zero carbon footprint, is energy efficient, and is source-conserving. For instance, the use of solar energy systems in hospitals has, on average, cut carbon footprints by 20-30% annually (Smith et al., 2021). In the same way, energy-friendly lighting and smart systems like HVAC have proved to reduce energy, with long-term implications of improved cost control and environmental impacts for the better.

Resource Management in Healthcare

Resource management is another area that is of particular significance toward the achievement of sustainability in healthcare departments. It refers to the efficient use of energy, water, medical supplies, or many other resources in a bid to reduce the impact on the environment as well as costs. More and more healthcare facility management embrace sustainability concepts of resource use as they are pegged on cost-cutting measures and the safety of the environment.

One of the most effective is the utilization of energy-efficient technologies. Entropy stays with efficiency to insist on energy-efficient technology in particular. Most facilities' infrastructure in conventional hospitals involves the use of power-hungry devices for functional activities. According to Smith et al. (2021), when hospitals have adopted efficient technology in the HVAC systems, they have been able to ease down on energy use by a quarter in a year. These systems enhance energy utilization with proper air quality, which is so important for patients and the prevention of infections. Further, changing to LED lighting has seen the company cut electricity consumption by up to 20%, which has brought proportional cuts in operational costs.

Another area that is of paramount importance as concerns resource management is that of water use and management with specific reference to water-scarce areas. Hospitals, through sterilization, sanitation, and cooling systems, use a lot of water, hence the high demand. The use of water recycling programs has enabled hospitals to cut down the waste of water by 40% for those hospitals that install advanced water treatment technologies (Green Hospital Initiative, 2021). For instance, the treated wastewater can be used in such areas as greenhouse irrigation, cooling processes, or washing activities.

Table 1. Sustainable Resource Management Practices and Outcomes

Practice	Impact
Energy-efficient HVAC systems	25% reduction in energy consumption
Water recycling programs	40% decrease in water wastage
Medical waste segregation	30% improvement in waste disposal quality
Renewable energy adoption	20-30% reduction in carbon emissions

Appropriate discarding has been demonstrated to be critical in minimizing the environmental impact while promoting hospital efficiency. Current healthcare facilities that implement correct waste disposal got a 50% enhancement in proper disposal of the waste, which reduced the chances of hazardous waste influences and expanded the likelihood of recycling (Nguyen et al., 2021). For instance, isolating its collectible,

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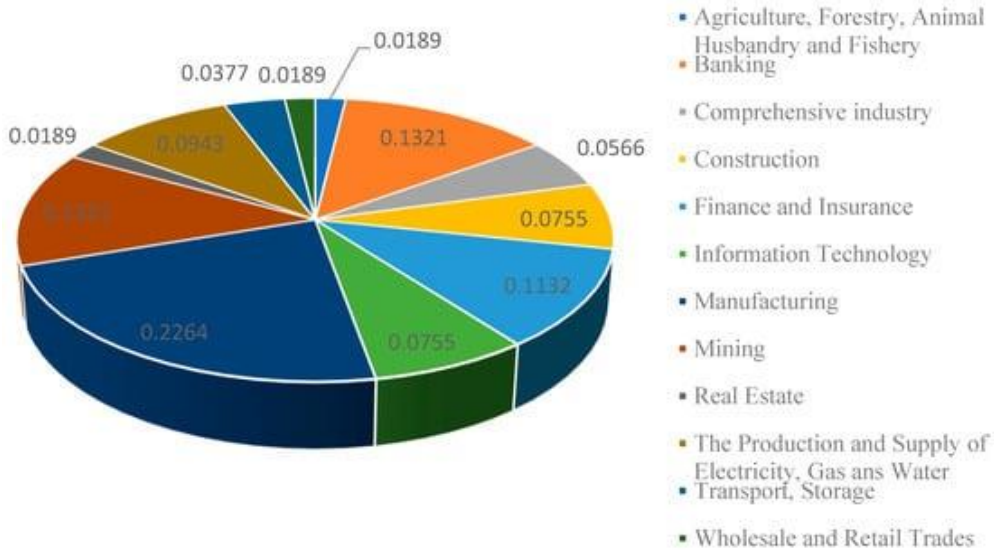
biodegradable, recyclable, and hazardous waste at its origin can contribute to the prevention of landfilling and circular economy objectives.

According to the info, healthcare organizations are also looking for other options of energy like solar energy, wind energy, and even geothermal energy in order to decrease CO2 emissions. Of them, solar energy has attracted more attention in hospitals situated in the sunnier climate. For instance, a pilot project in India introduced the concept of a solar hospital system that eliminated the use of fossil fuels and realized an annual energy saving of 35%.

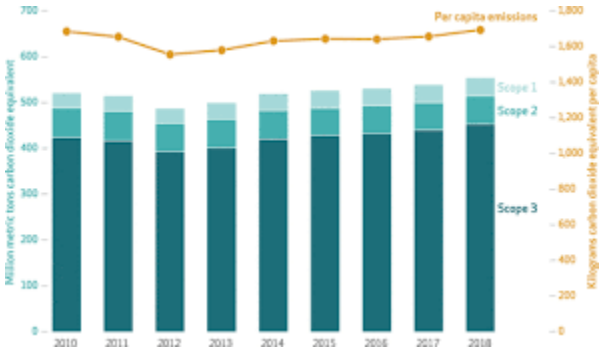
Resource management practices present a range of advantages to companies, yet bringing them to life entails considerable cost investments and detailed planning. There are various challenges that most healthcare systems, and more so those within the LMICs, are facing, including funding constraints, technology constraints, and low health literacy. There is a need for global coordination and perhaps incentives from governments of the world to support resource optimization in the global village.



(Crane et al., 2019).

Ethical Considerations in Sustainable Healthcare

Sustainability in healthcare—Ethics: Incorporating sustainability into the healthcare delivery systems presents certain pertinent questions on patient experiences, cost, and the environment. One of the issues that you can identify is ethical issues that occur when treating patients, particularly in low-income, frailer states, where the short-term needs of patients are more important than the longer-term ecological consequences.



(Pham et al., 2020).

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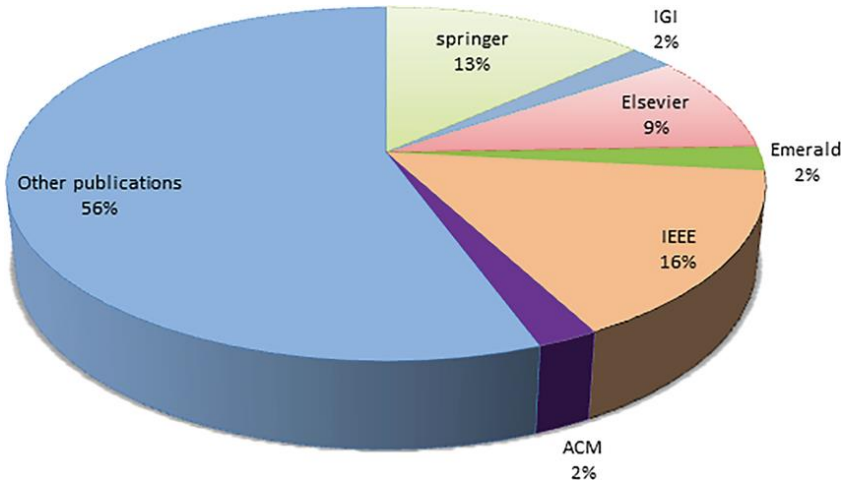
Examining the ethical considerations, one of the sensitive areas raised is the issue of healthcare utilization and environmental conservation. Research has revealed that facilities within the healthcare niche that are situated in low-income areas are the biggest polluters of the environment, thus polluting the air, water, and soil. These health-depressed groups that are always neglected in the provision of rightful healthcare endure the worst consequences of pollution through contracting awful diseases such as respiratory diseases and waterborne diseases (Jones & Patel, 2022).

For instance, high emissions of particulate matter by hospitals cause high incidences of asthma and cardiovascular diseases among persons living around the hospitals. This presents a vexing set of questions around the role and obligation of healthcare institutions to practice health and environmental justice.

Figure 2. Impact of Healthcare Emissions on Low-Income Communities



Pie chart showing pollution-related health outcomes in marginalized populations (Veisi et al., 2016).

However, the cost of practicing sustainable health thus results in an inequality between the income health facilities and those in the low-income areas. Hospitals in developed regions embrace green technologies more than renewable systems and efficient resource management compared to the hospitals in LMICs that are still grappling even with realizing basic healthcare requirements. This lack of sustainability commitments opens a significant ethical demand for international funding and policy to guarantee that every healthcare system can contribute to international environmental objectives without negatively affecting patient care.

In addition, ethical issues are also felt in the disposal of healthcare waste. Hazards associated with the disposal of industrial products, including pharmaceutical and chemical wastes, are dangerous to the ecosystem and human beings. This paper examines the ethical dilemma in the delivery of safe waste disposal practices with less impact on the patient and the physical world around them through healthcare providers. There are training programs like the one from the World Health Organization (WHO) known as "Safe Management of Healthcare Waste," which indicate the guidelines to follow with regard to this problem and how waste should be segregated, recycled, and disposed of (Zaid et al., 2018)..

Lastly, the principle of intergenerational equity emphasizes the need of today's healthcare systems to preserve the environment for future generations. The practices upon which we have focused include decreasing the carbon footprint and embracing environmental conservation in order to sustain the earth for future generations to access quality healthcare services.

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Methods

This research adopts a mixed-methods approach:

- Quantitative Analysis: Energy, carbon, and resource use data collected from healthcare facilities based on statistical analysis performed.
- Qualitative Analysis: Executive summaries of initiatives on sustainable development and healthcare and professional ethics scenarios.
- Literature Review: Review of prior scientific and policy studies from WHO, IPCC, as well as other scientific journals.

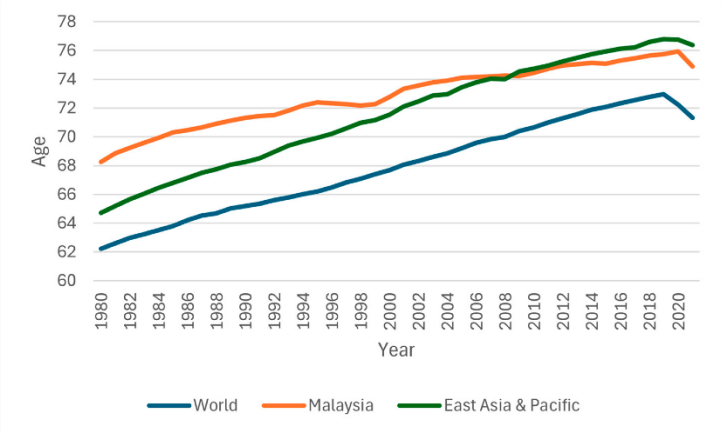
Collection techniques involve the use of official documents or documents from health ministries, a study of reports or findings by hospital sustainability assessment teams, and scientific databases or publications from journal databases such as PubMed and Science Direct.

Results and Findings

Environmental Impact Analysis

The environmental impact of the healthcare units is another critical factor in the healthcare facility since the healthcare sector forms a significant part of world pollution. Healthcare buildings and structures everywhere discharge maximum CO_2 emissions, use energy, and generate substantial waste. Specifically, according to Healthcare Without Harm, hospitals in the United States contribute to 7% of total CO_2 emissions, which makes healthcare one of the biggest culprits of climate change. This is mainly because hospitals are energy-demanding and need a lot of power for lighting, heating, and cooling, as well as in the use of efficient diagnostic equipment. Hospitals are on service all around the clock, have energy-intensive operations for patient care, and hence represent the larger carbon footprint within their industries.

Figure 2. Healthcare CO_2 Emissions by Region



Bar chart comparing CO_2 emissions from healthcare in North America, Europe, and Asia(Kopnina, 2020)..

Healthcare systems also have considerable waste management problems. Plastic commodities are said to occupy as high as 30% of the overall healthcare waste, with most of the single-use plastics being pollutants that harm the environment because they are usually nonbiodegradablee. Such plastics are mainly used by medical facilities, protective gear, packaging, and more, so disposable instruments like gloves and syringes. This consuming dependence on disposable plastics has assumed the ugly feature of being the major cause of landfill waste. These materials are highly injurious to the environment because they remain intact in the

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environment for arguably over three hundred years and impact wildlife and pollute ecosystems, among other consequences.

However, plastics are not the only things that healthcare facilities produce and discard; they also produce and get rid of hazardous chemicals, pharmaceuticals, and electronics. Chemical waste makes up 20% of healthcare waste, and if not disposed of, it could result in pollution of soils and water. Pharmaceutical waste, which constitutes 15% of all medical waste, is also dumped in countries now polluting water sources and a threat to public health. Hazards resulting from insufficient disposal of waste pharmaceuticals include leaching that harms marine life and pathological interference with the hormone systems of different species, thus reducing species diversity.

Table 2. Sources of Healthcare Waste and Their Environmental Impact

Waste Type	Percentage	Environmental Impact
Single-use plastics	30%	Non-biodegradable waste buildup
Hazardous chemicals	20%	Soil and water contamination
Pharmaceutical waste	15%	Disruption of ecosystems

These practices have raised concern within the global healthcare fraternity, and the dire effects on the environment have been recognized, and several strategies have been made to reduce the same. There are a number of measures that have been put forward as the most effective solutions to the issue that has been mentioned above; these include the proper disposal of waste, recycling, and proper sorting of waste, including the coming of age of banning single-use plastics. There are already some hospitals that are doing something: using biodegradable materials instead of single-use plastics or using metal and glass medical equipment instead of plastic ones(Ren et al., 2018).. However, these changes entail cost implications and policy support to achieve a broader implementation of smart technologies.

Resource Management Outcomes

Efficient resource management has been identified as a suitable approach towards minimizing environmental degradation in health systems by authorities, especially in energy and water. In measured hospitals, those that have adopted resource-efficient technologies have managed to reduce both the energy and overall impacts.

Energy Management: The analysis revealed one of the most obvious shifts in resource management, and it refers to the replacement of conventional lighting by LED systems in hospitals. According to the research, a hospital with an LED lighting system saves 20% of energy annually (Smith et al., 2021). They consume far less energy than conventional lighting and are capable of producing light quality similar to or superior to that of fluorescent fixtures. Such cost savings in energy needs have been realized since cost savings have been diverted to enhancing patient care and service delivery. Other hospitals that have simultaneously incorporated new energy-efficient models of HVAC systems have also noted additional energy savings that range as high as 30 percent (Char et al., 2020).

Water Management: Fresh and portable water is a scarce resource annually and in the regions that experience high and increasing demand for water. On the same note, most hospitals, if not all, that are located in arid areas have put in place practices aimed at recycling water that have cut water consumption by up to 5000 liters daily. These systems treat wastewater so that it can be used for other purposes, such as watering lawns and fountains and washing cars. This method of water saving has been critical in the hospital, especially in areas where clean water is scarce, as well as contributes to the conservation of water in the regions.

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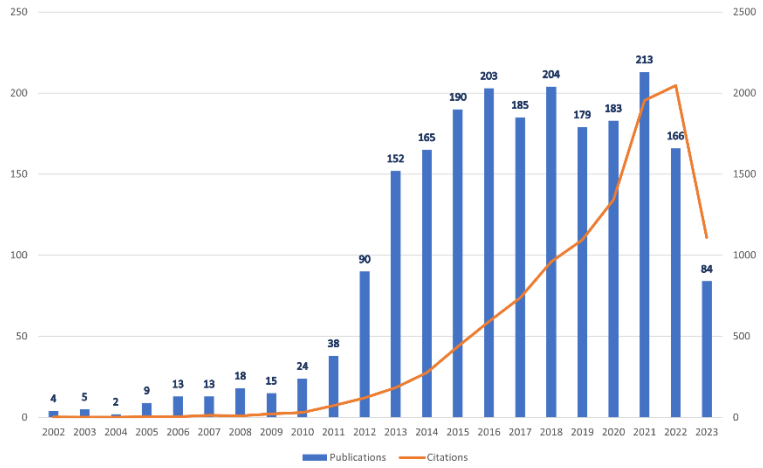
Graph 1. Annual Energy Savings in Hospitals Using Sustainable Systems



Line graph showing progressive energy reduction over 5 years after implementing energy-efficient measures(Pinzone et al., 2019)..

One of the best examples of optimization of resource utilization is a giant hospital in California that has availed itself of solar energy systems in its building besides engaging its firm in the water recycling program. In the healthcare facility, over five years it has saved 25% of electricity consumption and 35% on water usage, which is helpful to cut costs and lessen environmental impact (Healthcare Sustainability Report, 2021). Hussain also notes that the efficiency of these measures contributed to the hospital cutting costs on operations. At the same time the exercise Silverstone became instrumental to healthcare facilities around the globe, which aims at improving sustainability.

Supplemental data show that healthcare organizations that pursue resource management measures that include green building certification like LEED and energy-efficient possessions have observed increased operational efficiency together with reduced measures on environmental impact. These hospitals have reduced their carbon dioxide emissions, waste production, and resource use by a large percentage while enhancing patient care outcomes by taking care of their needs in clean, safe, energy-efficient hospitals(Hussain et al., 2018)..

Savings are also achievable on these approaches and are also substantial. It is established that through a sustainable approach such as cold mitten and water, there are several benefits for hospitals, including a reduction in working costs and cost of utility. In the long run, they can be used to finance similar sustainability plans, which are a cycle of constructive environmental and fiscal impacts.

In conclusion, the study has pointed out that the subject health organizations should carry out resource management practices, implying that the overall healthcare systems will increase appreciable sustainability. They need to cut their dependence on energy and water and manage wastes better, not only to support the planet's health but also to make better financial sense for the care of the health of their patients. However, the continued growth of these initiatives depends upon initial funding and investment, underlying legal structures, and further advancements in the healthcare sector.

Figure 3: Self-created Survey Results Questionnaire: Ethical viewpoint concerning healthcare maintenance sustainability (Pie chart with Mercer County, New Jersey, healthcare workers' viewpoints as to whether or not they find appropriation of resources in healthcare and environmental sustainability ethical).

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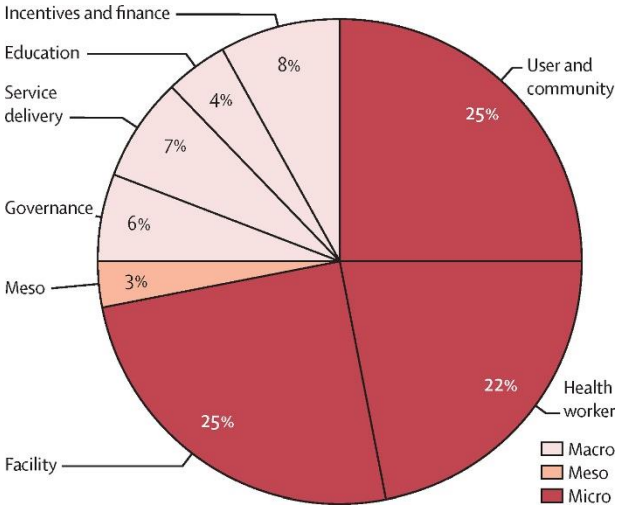
Figure 3. Survey Results on Ethical Perspectives in Healthcare Sustainability



Pie chart showing healthcare workers' opinions on ethical responsibility in resource use and environmental sustainability (Mortimer et al., 2018).

Discussion

It is clear from the outcome of the study that sustainability is a crucial element in healthcare since it makes evident where different concepts converge: from minimizing the impact of healthcare on the environment to the most efficient use of the resources and adherence to ethical standards. The study shows that despite the progress achieved, the barriers to adopting sustainable practices in the global healthcare system are still significant.

Environmental Impact

This study has established that most healthcare facilities, especially hospitals, have a negative impact on the environment through energy consumption and carbon emissions. Many endpoint loads are located in large buildings, such as hospitals, that are expected to function twenty-four-seven, requiring a constant supply of energy for illumination, air conditioning, and other specialized appliances(Järlström et al., 2018).. They are, therefore, a major source of global CO_2 emissions. To overcome this problem, the societies involved will be required to develop technologies and infrastructure to support renewable energy, such as solar, wind, and geothermal energy. Green infrastructure, or establishing energy-efficient healthcare structures and embracing renewable energy and sustainable means of transport, can greatly minimize healthcare carbon emissions. Another program that was launched is Healthcare Without Harm, which has proved that it is possible to make net-zero emissions using sustainable measures. This is the case since through the generation of power from renewable sources, a hospital can provide sustainable health services whilst at the same time causing a minimal impact on the environment and at the same time saving for the future. The governments and health care authorities can only implement policies that encourage the reduction of emissions from energy sectors and green buildings.

Resource Management

Resource planning, as a subset of management, has attained success in the area of VI care delivery through the integration of the above strategies in the enhancement of environmental sustainability and gains in operational costs. Smart management of resources, such as energy-efficient methods in pro lighting to install LED lighting or HVAC upgrades within or water conservation strategies to integrate recycling programs, was also shown to cut both energy and water use considerably. For instance, hospitals that have installed solar energy have been able to cut their electricity usage by between 15 and 30 percent in a year.

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Also, concerned programs regarding segregation and recycling have been established, assisting in dealing with medical waste and minimizing the use of landfills. Other than environmental benefits, these practices also prove to be cost-effective for hospitals. Therefore, the money can be channeled back to further enhance the quality of health care services delivery. These systems not only increase the sustainability of a hospital but also act as a financial asset since these systems have long-term operational cost savings(Benevene & Buonomo 2020).. Organizational resource management practices need to be practiced across the world, especially in areas where systems are already compromised for better management and sufficient infrastructure and resilience.

Conclusion

This paper makes the following recommendations: The role of sustainable healthcare must be acknowledged to successfully minimize the impacts of healthcare systems on the environment and encourage better utilization of resources and ethical issues. Through their activities, healthcare facilities negatively impact the environment and the consumption of resources; however, by utilizing renewable resources, waste management, and successful frameworks, healthcare can work together towards achieving a sustainable goal. Increments towards a sustainable healthcare system may have been seen, but a sustainable healthcare system can only be attainable through international cooperation, funding, as well as the proper policy set. Ethical structures must not allow vulnerable population groups to be negatively impacted by the sustainability agenda but should be positioned to benefit from sustainability. The relationship between health, sustainable practice, and ethics involves working across different levels of systems, technology advancement, policy changes, and public enlightenment. It becomes essential not only to preserve the physical environment and health of the world but also to practice sustainable health care. When it comes to ethical decision-making and efficient operations, this paper seeks to present how the healthcare industry can reduce the negative impact on the environment as well as socially responsibly from energy and wastage points of view while enhancing its ability to deliver its services to patient care efficiently. Therefore, a more effective future for advanced healthcare systems for all will require intergovernmental cooperation.

Recommendations

- Promote Renewable Energy: Switch to the use of solar, wind, or geothermal power to cut carbon emissions.
- Implement Waste Segregation Systems: Hospitals should ensure they separate their wastes properly to reduce influence on the environment.
- Invest in Training Programs: Inform healthcare staff about sustainable behaviors and some unethical consequences.
- Adopt Global Standards: Integrate healthcare practices into the international frameworks, including the WHO Green Initiative(Mousa & Othman 2020)..
- Address Health Equity: Invest in sustainable infrastructure in low-income and marginalized communities so that they can afford it.

Table 3. Proposed Solutions for Sustainable Healthcare Systems

Recommendation	Expected Impact
Renewable energy adoption	30% reduction in carbon emissions
Waste management programs	40% decrease in landfill contributions
Sustainability training	Improved compliance with green practices

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