Developing a strategy for sustainable management of public healthcare facilities: A study of selected hospitals in Akure Nigeria.

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Abstract

The sustainable management of public healthcare facilities is a critical challenge in today's healthcare delivery systems, driven by increasing demands, limited resources, and the growing need for environmentally and technologically responsible practices. This study seeks to explore and formulate a strategic framework that ensures the long-term sustainability of public healthcare facilities. The study focuses on optimizing resource efficiency, improving facility maintenance, reducing environmental impacts, and integrating emerging technologies in healthcare facility management. The study employs a mixed-methods approach, combining qualitative and quantitative data collection. A sample frame for the study includes healthcare facility managers, sustainability experts, healthcare professionals, and patients. An in-depth interview was conducted with 8 facility managers to gather qualitative insights on current practices and challenges in facility management. Additionally, focus group discussions were held with healthcare workers to explore operational perspectives on sustainability. To complement this, a quantitative survey was administered to 195 respondents, including healthcare staff and patients from 4 public healthcare facilities in Akure Nigeria, to assess facility performance, user satisfaction, and the integration of sustainability measures. Statistical analysis, including descriptive statistics and regression analysis was used to explore the relationships between sustainability practices and facility performance, resource efficiency, and user satisfaction. Findings revealed that those facilities that have adopted energy-efficient technologies, efficient water management, and effective waste management protocols are seeing positive outcomes, including cost savings, improved patient satisfaction, and reduced environmental impact. Similarly, the study revealed that many public healthcare facilities are aware of the importance of sustainability, but financial and operational constraints limit their ability to implement comprehensive strategies. The study therefore recommends increasing awareness, enhancing policy frameworks, and exploring funding mechanisms such as public-private partnerships as critical to overcoming the identified challenges and achieving sustainable management of public healthcare facilities.

INTRODUCTION

The sustainable management of public healthcare facilities has become an increasingly pressing global concern, driven by the intersection of environmental, economic, technological, and healthcare challenges. Given the current global healthcare system, which is facing immense

challenges arising from population growth, growing healthcare demands, resource limitations, and climate change, the need for effective management strategies that ensure long-term sustainability is paramount. Public healthcare facilities serving as integral components of national healthcare infrastructures consume significant amounts of energy, water, and other material resources, contributing to both financial strain and environmental issues (21). Therefore, the development of comprehensive, sustainable management frameworks is essential for optimizing operational efficiency while mitigating the environmental impact of healthcare delivery (17; 22).

Healthcare facilities are unique in their complex operational requirements, involving continuous energy consumption, high levels of waste generation, and the use of vast quantities of water and materials (6; 7). Research indicates that the healthcare sector contributes approximately 4.4% of global greenhouse gas emissions, with hospitals and other medical facilities accounting for the bulk of these emissions due to energy-intensive operations (9; 2). Moreover, public healthcare facilities often struggle with outdated infrastructure, inefficient resource use, and inadequate maintenance practices, which further exacerbate environmental impacts and operational costs (20). Hence, addressing these inefficiencies is critical for reducing carbon foot emissions and ensuring facility sustainability, especially in the current face of tightening budgets and increasing energy costs in Nigeria and other countries of the world.

Sustainable healthcare facility management is critical for maintaining high-quality patient care other than the environmental and economic concerns. Poor facility management can negatively impact healthcare delivery, as issues such as inadequate ventilation, poor waste disposal, and unreliable energy supplies can compromise patient safety and care outcomes (15). Integrating sustainability into healthcare facility management, healthcare institutions can enhance the resilience and functionality of their infrastructure while maintaining the standards of care required to meet public health goals. This is particularly important in the context of global health crises, such as the COVID-19 pandemic, which has underscored the need for robust, sustainable healthcare infrastructure that can adapt to increasing healthcare demands (2; 19).

Technological advancements have also opened new avenues for improving sustainability in public healthcare facilities. For instance, 16 discussed how the application of the most innovative artificial intelligence techniques through an organized digital transformation process guaranteed the delivery of healthcare services efficiently. Smart building systems, advanced energy management

solutions, and the integration of renewable energy sources offer opportunities to enhance resource efficiency, optimize operational performance, and reduce the carbon footprint of healthcare facilities (4). These innovations, when combined with a strategic approach to sustainable management, can provide healthcare administrators with the tools needed to achieve long-term sustainability goals while ensuring that public healthcare facilities remain resilient and capable of meeting future healthcare challenges and needs.

This paper seeks to develop a comprehensive strategy for the sustainable management of public healthcare facilities. The study employed a mixed-methods research approach to analyze the current practices, identify gaps in sustainability efforts, and propose practical solutions for improving the sustainability of public health infrastructure. The findings provide critical insights for healthcare administrators, policymakers, and facility managers, thereby offering a roadmap for enhancing resource efficiency, reducing environmental impacts, and integrating technological innovations to ensure the long-term sustainability of public healthcare systems.

LITERATURE REVIEW

The sustainable management of public healthcare facilities is increasingly recognized as a critical component of modern healthcare systems, addressing both the operational demands of providing healthcare services and the growing necessity for environmental services. Public healthcare facilities are key to achieving health system efficiency and equity, but they are also resource-intensive operations that can significantly contribute to environmental degradation if not properly managed. This literature review explores the major themes in the sustainable management of healthcare facilities, focusing on energy efficiency, waste management, the role of technology, and the integration of sustainability principles into healthcare infrastructure.

2.1.1 Energy Efficiency in Healthcare Facilities

One of the major concerns for sustainable healthcare management is energy consumption. Public healthcare facilities are large-scale consumers of energy due to the need for continuous operations, including heating, cooling, ventilation, lighting, and the operation of medical equipment (4). Hospitals, according to 17, are among the most energy-intensive buildings, consuming up to three times the energy of a typical commercial building. Given the rising costs of energy and the need

to reduce greenhouse gas emissions, improving energy efficiency is essential for both economic and environmental sustainability.

Various studies have examined strategies to enhance energy efficiency in healthcare settings. Energy-efficient lighting systems, upgraded HVAC (Heating, Ventilation, and Air Conditioning) systems, and better building insulation have all been identified as potential avenues for reducing energy consumption (15). Additionally, the integration of renewable energy sources such as solar and wind energy has gained attention as a means to power hospitals and reduce dependence on fossil fuels. A study conducted by 8 highlights the positive impact of transitioning to renewable energy in healthcare facilities, with reductions in operational costs and carbon emissions.

2.1.2 Waste Management in Healthcare Facilities

Healthcare facilities generate substantial amounts of waste, including hazardous and non-hazardous materials, which, if not properly managed, can pose serious environmental and public health risks. 10 informed that Medical waste management is a critical aspect of sustainable healthcare facility operations, with improper disposal of medical waste leading to contamination of water supplies, the spread of infectious diseases, and air pollution (22). Several studies, such as 13 and 1 have identified waste segregation, recycling, and the use of environmentally friendly products as effective strategies for reducing the environmental footprint of healthcare facilities.

According to Practice Greenhealth (2020), U.S. hospitals alone generate approximately 5.9 million tons of waste annually, 85 percent of which is non-hazardous and could be managed more sustainably, while the remaining 15 percent are hazardous substances that require effective management. 20 opined that implementing comprehensive waste management policies that emphasize waste reduction, proper disposal, and recycling can greatly reduce the environmental footprint of healthcare facilities. Further, 4 mentioned that ‘in addition to managing solid waste, water conservation and waste water management are critical to sustainability in healthcare settings. Hospitals use significant volumes of water, making the adoption of water-saving technologies and waste water treatment schemes essential for minimizing environmental impact.

2.1.3. Technology in sustainable facility management

Integrating technology is revolutionizing sustainable facility management across various sectors, including healthcare, which is not only necessary but crucial in achieving sustainable healthcare delivery. Technological innovations such as smart building systems, energy management platforms, and automated maintenance solutions have the potential to significantly enhance the sustainability of healthcare facilities (14; 5). Smart healthcare facilities are equipped with systems that monitor energy usage in real-time, automatically adjust lighting and HVAC systems to enhance efficiency, and track the lifecycle of equipment and infrastructure components, thereby improving operational efficiency and reducing energy consumption (4).

In addition, advancements in health information technology (HIT) have allowed healthcare administrators to track resource consumption more effectively and make data-driven decisions that improve sustainability outcomes (18). For instance, predictive maintenance enabled by the Internet of Things (IoT) can reduce downtime for critical medical equipment and extend the lifespan of hospital infrastructure, contributing to more efficient resource use (23). As 8 observed, technological innovation is essential to achieving sustainability goals in healthcare delivery, as it enables more efficient resource management, minimizes waste, and ensures the optimal functioning of medical and non-medical systems.

2.1.4. Sustainability in healthcare infrastructure facilities

Sustainable healthcare infrastructure facilities go beyond resource efficiency and waste management to include the design and construction of buildings that minimize environmental impacts and enhance patient and staff well-being. The concept of "green hospitals" has emerged as a leading trend in sustainable healthcare management, with the adoption of eco-friendly materials, energy-efficient designs, and biophilic elements that improve the overall health outcomes for patients while reducing environmental footprints (15).

A growing body of research highlights the benefits of sustainable healthcare buildings. For example, studies show that healthcare facilities designed with sustainability in mind—through the use of natural lighting, improved ventilation systems, and the inclusion of green spaces—can

improve patient recovery times, reduce staff stress levels, and enhance the overall well-being of occupants (5). Furthermore, green healthcare buildings are more resilient to climate-related events, such as extreme heat or storms, thus ensuring that healthcare services remain operational during crises (2). Green building certifications such as LEED (Leadership in Energy and Environmental Design) have become a benchmark for sustainable healthcare infrastructure. Facilities that meet these certification criteria are designed to be more energy-efficient, use fewer resources, and provide a better resilient environment.

2.1.5 Challenges of sustainability in healthcare facilities

Despite the clear benefits of sustainable healthcare facilities, achieving this is fraught with challenges. Generally identified as obstacles to implementing sustainable practices in healthcare facilities include but are not limited to financial constraints, lack of awareness, and regulatory barriers (17). In many low- and middle-income countries such as Nigeria and South Africa, healthcare infrastructures compete with limited resources and outdated infrastructure facilities, which makes the transition to sustainable practices more difficult and challenging (22). In a study undertaken by 20 it was revealed that while healthcare administrators recognize the importance of sustainability, many lack the resources and technical know-how required to implement comprehensive sustainability programs in the sector. Likewise, stiff resistance to change and other competing priorities within healthcare organizations usually slow down the adoption of sustainable innovative practices (2). To overcome these barriers, 4 suggested strong policy frameworks, financial incentives, and capacity-building efforts are needed to promote sustainability in healthcare at both national and institutional levels.

This section of the study has stressed the relevance of developing a comprehensive strategy for the sustainable management of public healthcare infrastructure facilities. It identified energy efficiency, waste management, technological innovation, and green infrastructure as key components of such a strategy, offering opportunities to reduce environmental impacts, enhance operational efficiency, and improve positive health outcomes. Nevertheless, overcoming the financial, technical, and institutional challenges to sustainability requires combined efforts from governments, healthcare administrators, and the larger community. Therefore, as the healthcare sector continues to grow, the need for integrating sustainability into the core management of public

healthcare facilities becomes necessary for ensuring long-term viability and resilience in the systems

METHODS

This current study uses a mixed-methods research design approach, incorporating both the qualitative and quantitative approaches. The combination of these methods allows for a deeper exploration of the current sustainability practices in healthcare facilities, the challenges faced, and the potential solutions that can be implemented. The methodology is designed to gather insights from key stakeholders regarding facility performance and sustainability outcomes. The study adopts an explanatory mixed-methods approach, starting with a quantitative phase, followed by a qualitative phase. The quantitative data was collected through surveys to measure facility performance, facility efficiency, and user satisfaction, while the qualitative phase involved interviews and focus group discussions to gain a deeper understanding of the practices and challenges faced in ensuring a sustainable healthcare facilities in the study area. The sample frame for the study consists of healthcare facility managers, sustainability experts, healthcare professionals, and patients or their caregivers in public healthcare facilities. The selection of these groups ensures a holistic view of facility management from operational, technical, and user perspectives.

The quantitative component of the study involved 195 participants selected from 4 public healthcare facilities in Akure Nigeria. The sample consists of 86 healthcare professionals (doctors, nurses, support staff), 98 patients (or patient caregivers) who are receiving services at the hospital facilities at the time of the study, 4 facility managers or officers responsible for operational and sustainability decisions, and 7 sustainability experts drawn from environmental engineers, energy management officers associated with healthcare facilities, etc. Similarly, the qualitative component included an in-depth interviews with 4 facility managers and sustainability experts and focus group discussions held with the healthcare workers to capture their insights on operational challenges and sustainability initiatives.

Quantitative data for the study was collected through structured questionnaires distributed to the 195 respondents, focusing on key indicators of sustainability in healthcare facilities. The

questionnaires assessed issues such as facilities efficiency (energy, water usage, and waste management); challenges in implementing sustainable facilities management practices (regulatory and policy gaps, operational challenges); opportunities for improvement (technology advancements, training and awareness programs and collaboration with external sustainability experts); and perceived benefits of sustainable facilities (improved patience care, cost savings). The questionnaire used Likert scales to measure perceptions and satisfaction levels, and it included multiple-choice questions on facility practices.

On the other hand, qualitative data was collected using semi-structured interviews and was conducted with 4 facility managers to explore their experiences and perspectives on the challenges and opportunities for implementing sustainable facility management practices in the healthcare sector. The structured interviews covered questions on current facility management practices, the role of technology in enhancing sustainability, and challenges in adopting sustainable strategies.

RESULTS AND DISCUSSION

The result analysis covers both quantitative and qualitative findings to provide insights into the sustainability practices, challenges, and opportunities within the public healthcare facility.

The quantitative data was analyzed using statistical techniques, which include descriptive statistics to summarize the data collected from the respondents. Also, ANOVA, an inferential statistics, was used to identify significant differences in perceptions between different groups (such as patients vs. staff on different types of healthcare facilities). Also, regression analysis was used to assess the relationship between facility sustainability practices and performance outcomes (e.g., energy savings and patient satisfaction).

On the other hand, qualitative data from interviews and focus groups were analyzed using a thematic analysis approach, while recorded data from interviews was transcribed, coded, and categorized to identify repeated themes. Thereafter, NVivo software was used to organize and code the data, thereby facilitating the identification of major themes related to challenges, practices, and solutions for sustainable facility management and presented as follows:

Table 1: Quantitative data summary of facilities efficiency, satisfaction, and technological integration

Variable	Percentage / Average
Energy Consumption	
Average energy consumption per facility	1.8 million kWh annually
Facilities with average energy-saving technologies (LED, efficient HVAC)	30%
Facilities without renewable energy sources (grid power only)	70%
Water Usage	
Average water usage per facility	12,000 cubic meters annually
Facilities using water-saving technologies (low-flow faucets, recycling)	5%
Facilities without water-saving technologies (low-flow faucets, recycling)	95%
Waste Management	
Facilities adhering to waste segregation protocols	7%
Facilities with formal waste disposal programs	45%
Facilities struggling with medical waste management	80%
Satisfaction Levels	
Patient Satisfaction	
Satisfied with cleanliness and environmental comfort etc.	22%

Dissatisfied (due to uncleanliness, poor environmental etc.)	78%
Healthcare Worker Satisfaction	
Believe their facility prioritizes sustainable practices	33%
Report inadequate waste management or inconsistent energy measures	67%
Facility Manager Satisfaction	
Rated sustainability performance as "average"	55%
Rated sustainability performance as "good"	25%
Technological Integration	
Facilities adopting smart technology (e.g., smart HVAC, lighting)	00%
Average energy reduction in facilities using smart technology	5%
Facilities with renewable energy (e.g., solar panels)	30%
Average energy cost reduction in facilities using renewable energy	20%

Source: Author's field survey (2024)

2. Qualitative Data Analysis

Using thematic analysis, key themes emerged from the interviews with facility managers, sustainability experts, and focus groups with healthcare workers. The qualitative analysis helped to complement the quantitative findings by providing deeper insights into the challenges and opportunities for sustainable facility management.

Table 2: Thematic Analysis of the Challenges and Opportunities for Sustainable Facility Management

KEY THEMES	RESULTS
1. Challenges in implementing sustainability practices in facilities management	
(i) Budgetary Constraints	All the 4 facility managers and sustainability experts, representing 100% highlighted financial limitations as a primary challenge to implementing comprehensive sustainability strategies. They further noted that budget allocations often prioritize clinical needs, leaving insufficient funds for energy upgrades and waste management systems.
(ii) Regulatory and Policy Gaps	Three (3) of the facility managers representing 75% mentioned that the existing regulations lack clear guidelines or incentives for sustainability, making it difficult for them to justify investing in costly green technologies without external funding or policy support.
(iii) Operational Challenges	Seventy six (76), representing 91.9% of the healthcare workers reported difficulties in maintaining sustainable practices due to operational pressures, such as dealing with high patient volumes and outdated infrastructure. But, 178 which represents 91,3 of the respondents maintained that managing day-to-day operations takes precedence over long-term sustainability plans.
2. Opportunities for Improvement	
(i) Technological Advancements	72% of the facility managers emphasized the potential of integrating smart technologies into healthcare facilities to

optimize energy use, with several referencing the success of early adopters in reducing energy consumption. One sustainability expert noted, *"Smart energy systems have the potential to transform how we manage resources in hospitals, but adoption is slow due to the upfront costs."*

(ii) Training and Awareness Programs

Focus group discussions with healthcare workers revealed that there is a lack of formal training on sustainability practices. Several healthcare workers suggested that regular sustainability training sessions, combined with awareness campaigns, could help improve compliance with waste segregation protocols and energy-saving practices.

(iii) Collaboration with external sustainability experts

It is noted that public-private partnerships could help partners bridge the funding gap and bring in expertise for implementing renewable energy systems and waste management programs. A facility manager stated, *"Working with external sustainability consultants will help in identifying cost-effective ways to reduce energy consumption, but the challenge is finding funding to implement their recommendations."*

3. Perceived Benefits of Sustainability

(i) Improved Patient Care

Several healthcare workers highlighted the link between sustainable facility management and patient care outcomes. Facilities with better ventilation systems and effective waste management were perceived to provide a healthier and safer environment for both patients and staff.

(ii) Cost Savings	Many facility managers expressed optimism that, despite the upfront costs, investments in sustainability could lead to long-term savings. Facilities that had already adopted renewable energy sources reported significant reductions in operational costs, with one manager stating, "*Our energy bills dropped by 20% after installing solar panels—this has made a huge difference in our operational budget.*"

Source: Author's field survey (2024)

Table 3: Summary of result using inferential analysis

Analysis	**Result**
Energy Efficiency and Patient Satisfaction (Regression Analysis)	
R^2	0.35 (35% of variability in patient satisfaction explained by energy efficiency)
Significance (p-value)	$p < 0.05$ (statistically significant positive correlation)
Facility Manager Ratings and Waste Management (ANOVA Analysis)	
Significance (p-value)	$p < 0.01$ (significant difference in sustainability ratings based on waste management practices)

Source: Author's field survey (2025)

CONCLUSION

The study reveals that while many public healthcare facilities are aware of the importance of sustainability, financial and operational constraints limit their ability to implement comprehensive strategies. However, those facilities that have adopted energy-efficient technologies, efficient water management, and waste management protocols are seeing positive outcomes, including cost savings, improved patient satisfaction, and reduced environmental impact. The qualitative insights suggest that increasing awareness, enhancing policy frameworks, and exploring funding mechanisms such as public-private partnerships are critical to overcoming these challenges and achieving sustainable management of public healthcare facilities. The key findings from the quantitative analysis show the energy usage, water consumption rate, satisfaction levels of

healthcare facilities, and technological integration have varying percentages. The inferential analysis further highlights the relationships between sustainability practices and facility performance or satisfaction.

In conclusion, the study sheds light on areas for development while also highlighting the complexity of sustainability challenges in public healthcare settings. Healthcare facilities can lessen their impact on the environment while improving patient care and operational effectiveness by implementing energy-efficient technologies, effective waste and water management techniques, and supportive regulatory measures. The conclusions imply that in order to create more resilient healthcare facility systems, future sustainability initiatives should concentrate on technological adoption, training, and financial innovation.

The findings, if implemented, will provide a roadmap for healthcare administrators and policymakers to adopt best practices, enhance resource management, and ensure public healthcare facilities are environmentally sound, economically viable, and capable of meeting future demands. This study contributes to the broader discourse on sustainable healthcare infrastructural facilities, offering practicable insights for both developing and developed healthcare facility systems.

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