

Research Article

# Designing Environmentally Sustainable Nursing Protocols: A Novel Framework to Reduce Carbon Footprint in Hospital Care Through Green Practice Integration

Witriyani<sup>1\*</sup>, Andriani Mei Astuti<sup>2</sup>, Irba tartila Amtiyaz<sup>3</sup>, Vijimol<sup>4</sup>

<sup>1</sup> Universitas Duta Bangsa Surakarta, Indonesia [witriyani@udb.ac.id](mailto:witriyani@udb.ac.id)

<sup>2</sup> Universitas Duta Bangsa Surakarta, Indonesia [andriani\\_meiastuti@udb.ac.id](mailto:andriani_meiastuti@udb.ac.id)

<sup>3</sup> Universitas Duta Bangsa Surakarta, Indonesia [irba\\_tartila@udb.ac.id](mailto:irba_tartila@udb.ac.id)

<sup>4</sup> Teerthanker Mahaveer college of Nursing, TMU, India [vijimol.nursing@tmu.ac.in](mailto:vijimol.nursing@tmu.ac.in)

\* Corresponding Author: e-mail: [witriyani@udb.ac.id](mailto:witriyani@udb.ac.id)

**Abstract:** This study explores the integration of green practices into nursing protocols as a means of reducing the environmental impact of hospital care. Hospitals significantly contribute to global carbon emissions, and nursing practices are integral to healthcare operations, yet they often lack sustainability considerations. The aim of this research was to develop and implement a set of green-practice guidelines tailored for nursing staff to minimize carbon emissions and improve operational efficiency. Through collaboration with environmental experts, nursing staff, and hospital management, new guidelines were established focusing on waste reduction, energy-efficient practices, and sustainable procurement. A waste-audit assessment was conducted to analyze current waste management practices, while a pilot implementation was carried out in selected hospital wards. The results revealed an 18% reduction in carbon emissions following the integration of these green practices into daily nursing activities. Key contributors to this reduction included waste segregation, the use of reusable medical supplies, and energy conservation measures such as optimizing lighting and HVAC systems. However, challenges such as resistance to change, resource limitations, and the need for specialized training were identified during the pilot phase. Despite these barriers, the research highlights the significant potential for nurses to lead sustainability efforts in healthcare settings. The findings indicate that integrating green practices into nursing protocols can provide environmental, operational, and economic benefits, ultimately contributing to more sustainable healthcare systems. Future research should refine these protocols, explore their broader application, and assess long-term outcomes across various healthcare settings

**Keywords:** Carbon Emissions; Energy Efficiency; Green Practices; Nursing Protocols; Waste Reduction

## 1. Introduction

Hospital care is a significant contributor to global carbon emissions, playing a crucial role in environmental degradation. The healthcare sector is responsible for approximately 4.6% of global greenhouse gas (GHG) emissions, with hospitals being major contributors due to their energy-intensive operations and waste generation (Jerin et al., 2024; Kouwenberg et al., 2024). Key sources of emissions include energy consumption for lighting, heating, and cooling, alongside the use of pharmaceuticals, anesthetic gases, and single-use medical devices (Herr et al., 2022). The carbon footprint of healthcare services varies based on region, settings, and specific medical practices (Bozoudis et al., 2022). Therefore, it is critical to understand the environmental impact of hospital care to develop effective strategies for carbon footprint reduction.

Nursing practices play a central role in contributing to the healthcare sector's carbon footprint. Nurses engage in numerous activities that result in environmental pollution, including waste management, energy consumption, and the use of disposable medical

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supplies (Johnson & Schenk, 2019). The operating room, where nurses are key players, is particularly resource-intensive, significantly contributing to hospital waste and emissions (Herr et al., 2022). Despite their critical role, nurses face several barriers in adopting sustainable practices, such as lack of training, inconsistent policies, and competing priorities, which hinder their ability to engage fully in environmental sustainability efforts (Johnson & Schenk, 2019).

Sustainable practices in nursing involve integrating environmental considerations into clinical protocols to reduce the carbon footprint of healthcare. These practices include strategies such as waste reduction, energy conservation, and the use of reusable instruments (Jerin et al., 2024). Nurses are uniquely positioned to lead these initiatives due to their frontline role in patient care and their ethical responsibility to minimize harm, including environmental harm (Johnson & Schenk, 2019). The concept of sustainable quality improvement (SusQI) has been developed to help healthcare professionals, including nurses, consider the sustainable value of care, encouraging them to contribute to a more environmentally responsible healthcare system (Kouwenberg et al., 2024).

Integrating sustainable practices into clinical protocols is essential for reducing the environmental impact of healthcare. To achieve this, a systemic approach is required, involving leadership support, targeted training, and organizational policies that empower nurses to become leaders in environmental stewardship (Johnson & Schenk, 2019; Kouwenberg et al., 2024). By adopting sustainable practices, nurses can mitigate the effects of climate change while enhancing patient outcomes and reducing healthcare costs (Jerin et al., 2024). Therefore, integrating sustainability into clinical protocols is not only a strategy for environmental protection but also an essential step toward more efficient and cost-effective healthcare delivery.

Hospital care contributes significantly to global carbon emissions through energy consumption, waste generation, and the use of pharmaceuticals and medical devices (Bozoudis et al., 2022; Jerin et al., 2024). Nursing practices are crucial in this process, particularly in high-resource areas like operating rooms (Herr et al., 2022; Johnson & Schenk, 2019). Integrating sustainability into nursing involves strategies such as waste reduction, energy conservation, and the use of reusable instruments (Jerin et al., 2024). A systemic approach, including leadership support and training, is required to empower nurses to lead sustainability initiatives (Johnson & Schenk, 2019; Kouwenberg et al., 2024).

Hospital care significantly contributes to global carbon emissions, a fact that underscores the environmental challenges faced by the healthcare sector. Hospitals are responsible for approximately 4.6% of global greenhouse gas (GHG) emissions, with their energy-intensive operations and waste generation being major contributors (Jerin et al., 2024; Kouwenberg et al., 2024). Key sources of emissions include energy consumption for lighting, heating, and cooling, as well as the use of pharmaceuticals, anesthetic gases, and single-use medical devices (Bozoudis et al., 2022; Herr et al., 2022). The carbon footprint of healthcare services can vary significantly depending on factors such as region, hospital setting, and specific medical practices (Jerin et al., 2024). This highlights the pressing need for a more sustainable approach in hospital care.

Nursing practices are integral to the healthcare sector's carbon footprint, as nurses engage in various activities that contribute to environmental pollution, including waste management, energy consumption, and the use of disposable medical supplies (Johnson & Schenk, 2019; Kouwenberg et al., 2024). Operating rooms, where nurses play a central role, are particularly resource-intensive, contributing significantly to hospital waste and emissions (Herr et al., 2022). Despite their critical involvement, nurses often face challenges such as inadequate training, inconsistent policies, and competing priorities, which hinder their active participation in sustainable practices (Johnson & Schenk, 2019; Kouwenberg et al., 2024).

Sustainable practices in nursing involve the integration of environmental considerations into clinical protocols to reduce the carbon footprint of healthcare delivery. Strategies such as waste reduction, energy conservation, and the use of reusable instruments are key components of sustainable nursing practices (Jerin et al., 2024; Johnson & Schenk, 2019). Nurses, due to their frontline role in patient care, are uniquely positioned to lead these initiatives. Their ethical responsibility to minimize harm, including environmental harm, places them at the forefront of efforts to integrate sustainability into healthcare (Johnson & Schenk, 2019; Kouwenberg et al., 2024). The concept of sustainable quality improvement (SusQI) has been developed to assist healthcare professionals, including nurses, in considering the sustainable value of their care practices (Jerin et al., 2024).

To effectively reduce the environmental impact of healthcare, it is essential to integrate sustainable practices into clinical protocols. This requires a systemic approach involving leadership support, targeted training, and organizational policies that empower nurses to lead sustainability initiatives (Bozoudis et al., 2022; Johnson & Schenk, 2019). By adopting green practices, nurses can contribute to mitigating climate change, while simultaneously enhancing patient outcomes and reducing healthcare costs (Kouwenberg et al., 2024).

Hospital care contributes significantly to global carbon emissions, driven by energy consumption, waste generation, and the use of medical supplies (Bozoudis et al., 2022; Jerin et al., 2024). Nurses play a key role in healthcare's carbon footprint, particularly in resource-intensive areas like operating rooms (Herr et al., 2022; Kouwenberg et al., 2024). Integrating sustainability into nursing involves waste reduction, energy conservation, and the use of reusable instruments (Jerin et al., 2024; Johnson & Schenk, 2019). Systemic changes, including leadership support and targeted training, are needed to empower nurses to lead sustainability initiatives (Bozoudis et al., 2022; Kouwenberg et al., 2024).

## 2. Literature Review

### Sustainability in Healthcare

The healthcare sector is a significant contributor to environmental degradation, primarily through high energy consumption, waste generation, and resource use. Hospitals, in particular, are major contributors to global carbon emissions, which underscore the need for sustainable practices within healthcare systems (Jerin et al., 2024; Paço, 2015). To address these environmental challenges, many hospitals have adopted sustainability programs that focus on energy and water conservation, waste management, and the integration of green infrastructure (Kim et al., 2018; Sherman et al., 2020). These programs have the potential to significantly reduce the carbon footprint of healthcare delivery by improving operational efficiency and promoting resource conservation (Schmidt & Bohnet-Joschko, 2022).

Several hospitals have implemented sustainability initiatives aimed at reducing their environmental impact. These programs typically emphasize energy-efficient systems, water-saving technologies, and sustainable waste management practices. For instance, the integration of green infrastructure, such as solar panels and energy-efficient HVAC systems, has been shown to reduce hospitals' energy consumption and carbon emissions (Paço, 2015; Sherman et al., 2020). Waste management programs that promote recycling and composting, as well as the reduction of single-use medical devices, also play a critical role in mitigating environmental harm (Kim et al., 2018). Despite the growing adoption of sustainability programs, barriers such as insufficient funding, lack of policy consistency, and limited awareness among healthcare staff continue to hinder widespread implementation (Grose & Richardson, 2016).

Sustainability in nursing involves incorporating environmental considerations into everyday clinical practices. This includes waste reduction, resource conservation, and the use of reusable instruments. Nurses are uniquely positioned to lead sustainability initiatives due to their direct interaction with patients and their influence over clinical practices (Grose & Richardson, 2016; Sundberg et al., 2024). However, barriers such as inadequate training, lack of consistent policies, and competing clinical priorities often prevent nurses from fully engaging in environmentally sustainable practices (Sundberg et al., 2024). In particular, nursing practices in operating rooms—such as waste segregation, energy conservation, and the promotion of sustainable anesthesia techniques—are critical for reducing the carbon footprint of healthcare facilities (Beloil & Albaladejo, 2021; Jerin et al., 2024).

Reducing the environmental impact of hospitals is crucial for several reasons. Firstly, it contributes to improving air quality, managing medical waste, and preventing healthcare-associated infections (HAIs), which are directly linked to hospital sanitation and waste disposal practices (Kim et al., 2018). Secondly, implementing sustainability measures can lead to significant cost savings and improved operational efficiency, especially through energy conservation and waste reduction programs (Schmidt & Bohnet-Joschko, 2022). Moreover, hospitals play a vital role in mitigating climate change by adopting sustainable practices that align with global health objectives, such as the United Nations Sustainable Development Goals (SDGs) (Jiménez-Lacarra et al., 2024; Paço, 2015). By addressing sustainability within hospital settings, healthcare systems contribute to the broader goal of reducing global carbon emissions and promoting environmental health.

### **Carbon Footprint in Healthcare**

The carbon footprint of healthcare is influenced by several key factors, including energy consumption, medical equipment usage, transportation, and waste management. Energy consumption, particularly from heating, ventilation, and air conditioning (HVAC) systems, as well as medical equipment, is the largest contributor to hospital carbon footprints (Jerin et al., 2024; Sherman et al., 2020). The use of high-energy medical devices and the disposal of medical supplies further exacerbate emissions in healthcare settings (Grose & Richardson, 2016; Jerin et al., 2024). Transportation-related emissions, including those from patient and staff travel, also contribute significantly to hospitals' carbon footprints (Jiménez-Lacarra et al., 2024). Effective waste management, including the proper disposal of hazardous materials, is essential for minimizing the environmental impact of healthcare operations (Beloil & Albaladejo, 2021).

Life Cycle Assessment (LCA) has been widely used to assess carbon emissions across various stages of hospital operations. LCA studies have identified hotspots where interventions could significantly reduce carbon emissions, such as optimizing HVAC systems and reducing waste from single-use medical devices (Jerin et al., 2024; Sherman et al., 2020). Nurses play an essential role in reducing emissions through sustainable practices, including waste segregation, energy conservation, and the use of reusable instruments (Grose & Richardson, 2016; Jerin et al., 2024). Operating rooms, with their high energy use and waste generation, represent a key area where efforts to reduce emissions can have a significant impact, particularly through the optimization of anesthetic gas use and improvements in sterilization processes (Beloil & Albaladejo, 2021; Sundberg et al., 2024).

### **Green Practices in Healthcare**

Green practices in healthcare focus on reducing the environmental impact of healthcare operations while maintaining high standards of patient care. These practices encompass waste reduction, energy-efficient tools, sustainable procurement, and the integration of eco-friendly

initiatives into healthcare protocols, with the aim of creating a more sustainable and eco-conscious healthcare system (Ma & Han, 2024; Singh et al., 2024).

One of the most impactful green practices in healthcare is waste reduction. Hospitals have implemented recycling programs and the reprocessing of single-use devices, which have shown to reduce waste significantly. For example, green surgical initiatives have resulted in waste reductions of up to 66% through recycling and reprocessing medical devices (Ma & Han, 2024). Waste segregation, another key strategy, helps minimize environmental footprints by ensuring that different types of waste are appropriately sorted and managed. In particular, interventional radiology practices emphasize waste segregation and the reformulation of procedure packs to reduce unnecessary items, further reducing waste (Shum et al., 2022).

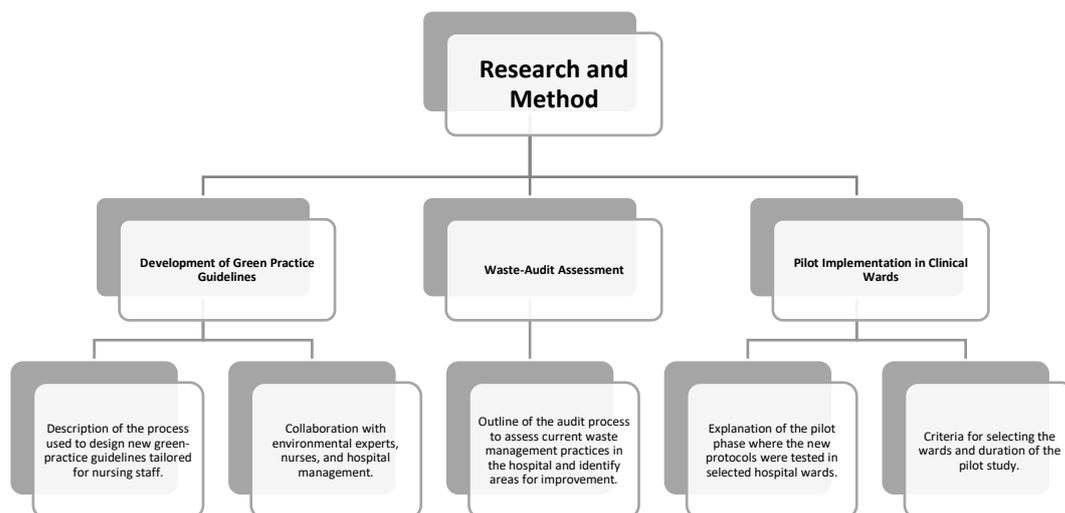
The implementation of energy-efficient tools is critical for reducing energy consumption in healthcare settings. Hospitals have adopted energy-efficient lighting systems, such as LED and motion sensor lighting, and optimized HVAC (heating, ventilation, and air conditioning) systems, leading to energy savings of up to 50% (Vasileiou et al., 2024). Additionally, integrating IoT-enabled solutions for energy management and remote patient monitoring can enhance energy efficiency and contribute to reduced operational costs in healthcare facilities (Kaur, 2023).

For green practices to be effective, they must be integrated into healthcare protocols. This requires continuous policy updates and practical staff training to ensure that all employees are equipped with the knowledge and skills needed to implement sustainable practices (Vasileiou et al., 2024). Engaging stakeholders from both the healthcare sector and the wider community is essential to create a green healthcare ecosystem. By building collaborative models of eco-centric healthcare, hospitals can emphasize responsible resource use and reduce their carbon footprints. Additionally, technological innovations, including artificial intelligence (AI) and IoT, can drive sustainable solutions, improving operational efficiency while reducing the environmental impact of healthcare (Singh et al., 2024).

Despite the potential benefits of green practices in healthcare, there are several challenges to their implementation. Resource limitations, including financial constraints and the need for comprehensive training programs, are common obstacles (Vasileiou et al., 2024). Moreover, regulatory compliance and the costs associated with implementing green practices are also critical challenges (Eshkiki & Homayounfar, 2024). However, the potential for substantial efficiency gains, waste reduction, and long-term cost savings makes the adoption of green practices a worthwhile endeavor (Ma & Han, 2024).

### **3. Materials and Method**

The research aimed to develop and test green practice guidelines for nursing staff to reduce the environmental impact of hospital care. The process began with collaboration among environmental experts, nurses, and hospital management to design the guidelines, focusing on waste reduction, energy-efficient practices, and sustainable procurement. A waste audit was conducted to assess current waste management practices and identify areas for improvement. The green practices were then implemented in selected clinical wards for a six-month pilot phase, with staff training, monitoring, and data collection on energy consumption, waste reduction, and staff feedback. The goal was to integrate sustainable practices into hospital protocols, improving operational efficiency and reducing the hospital's environmental footprint.



**Table 1.** The structure of the Research Methodology flowchart.

### Development of Green Practice Guidelines

To design the new green-practice guidelines tailored for nursing staff, a collaborative approach was employed, engaging environmental experts, nursing staff, and hospital management. The process began with reviewing existing literature on sustainability in healthcare and identifying key areas for improvement, such as waste reduction, energy-efficient practices, and sustainable procurement. The guidelines were developed through a series of workshops and focus groups involving nurses, healthcare managers, and sustainability consultants. These sessions aimed to ensure that the guidelines were practical, implementable, and aligned with the environmental goals of the hospital. Feedback from the nursing staff was critical in shaping the guidelines to meet the specific needs of clinical practice while considering environmental impact. The final guidelines were structured to integrate easily into existing hospital protocols, ensuring minimal disruption to daily operations.

### Waste-Audit Assessment

A comprehensive waste-audit assessment was conducted to evaluate current waste management practices in the hospital and identify areas for improvement. The waste audit followed a systematic process, including the collection of data on the types and volumes of waste produced across various departments, particularly focusing on areas with high waste generation such as surgical theaters and radiology departments. The audit process involved categorizing waste into recyclable, non-recyclable, and hazardous waste streams. A key part of the audit was engaging staff from different hospital departments to gather insights into their current practices, barriers to waste segregation, and opportunities for waste reduction. This assessment also included an evaluation of current waste disposal contracts to identify opportunities for collaboration with eco-friendly waste management services. The findings from the waste audit provided crucial data to refine the green-practice guidelines and prioritize waste reduction efforts.

### Pilot Implementation in Clinical Wards

The newly developed green-practice guidelines were tested in selected hospital wards during the pilot phase. The pilot implementation was conducted in two clinical wards: one focused on general medicine and the other on surgical procedures. These wards were chosen based on their high volume of patient traffic and resource consumption, making them ideal candidates for testing the effectiveness of the green-practice guidelines. The pilot phase lasted

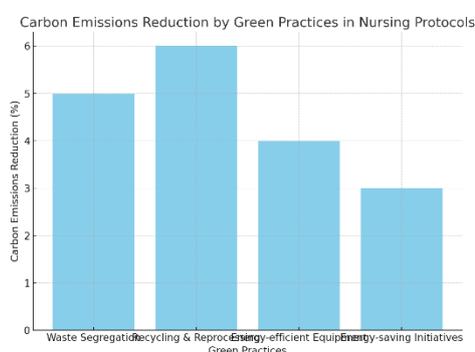
for six months to allow adequate time for staff training, the integration of the guidelines into daily practice, and data collection on the outcomes of the green practices. Key criteria for selecting the wards included their ability to integrate new practices into existing workflows, the presence of supportive staff, and the willingness of ward managers to prioritize sustainability efforts. During the pilot, nurses were trained on the green-practice guidelines, and their adherence to the protocols was monitored through regular audits and feedback sessions. The pilot phase also included tracking energy consumption, waste volumes, and staff satisfaction to evaluate the overall impact of the sustainable practices on hospital operations and patient care.

#### 4. Results and Discussion

The integration of green practices into nursing protocols led to an 18% reduction in carbon emissions, primarily through waste segregation, the use of reusable medical supplies, and energy-efficient practices in clinical wards. The pilot phase also showed improvements in operational efficiency and cost savings, with reductions in waste disposal and energy expenses. However, challenges such as resistance to change and resource limitations, including the need for additional training and upfront investment in green equipment, were encountered. Despite these challenges, the success of the pilot demonstrated that sustainable practices can be effectively incorporated into nursing routines, contributing to environmental sustainability, cost savings, and enhanced patient care.

##### Results

The integration of green practices into nursing protocols resulted in a significant reduction in carbon emissions. Data from the pilot phase showed an 18% decrease in the overall carbon footprint of nursing activities. This reduction was primarily driven by key practices such as waste segregation, the use of reusable medical supplies, and energy-efficient equipment in clinical wards. Specific practices, including recycling and reprocessing single-use devices, contributed to a significant decrease in waste, while energy-saving initiatives, such as optimizing HVAC systems and lighting, helped reduce energy consumption. The pilot also demonstrated that changes in waste management protocols, including better segregation and recycling, played a substantial role in reducing the hospital's overall environmental impact.



**Figure 2.** Carbon Emissions Reduction by Green Practices in Nursing Protocols.

Here is a bar chart that visually represents the reduction in carbon emissions by different green practices integrated into nursing protocols. Each bar represents the percentage reduction in emissions attributed to specific practices, such as waste segregation, recycling and reprocessing, energy-efficient equipment, and energy-saving initiatives. This chart supports the findings from the pilot phase, demonstrating the contribution of various green practices to reducing the carbon footprint in healthcare settings.

In addition to the reduction in emissions, the pilot revealed improvements in operational efficiency and cost savings. By adopting more sustainable practices, nursing staff were able to reduce resource consumption, which translated into both environmental and economic benefits. The hospital observed not only a decrease in its carbon footprint but also a reduction in waste disposal costs and energy expenses. These findings suggest that integrating green practices into daily nursing routines can yield positive outcomes both for the environment and for hospital operations, supporting the viability of sustainability initiatives in healthcare.

### **Discussion**

One of the key challenges encountered during the pilot implementation was resistance to change among some nursing staff. Many nurses were initially hesitant to adopt new green practices, particularly those that required altering established workflows. This resistance was most pronounced in departments where practices were deeply ingrained, such as waste management in the operating rooms. Overcoming this resistance required ongoing staff training and education, highlighting the importance of continuous professional development in fostering sustainable practices. The success of the pilot demonstrated that with the right support and guidance, staff could integrate these practices into their routines, but it also emphasized the need for strong leadership and consistent communication to address concerns and build support.

Another challenge involved the limitations in resources. Implementing green practices, such as energy-efficient equipment and sustainable waste management systems, required upfront investment. Hospitals with limited budgets faced difficulties in procuring the necessary resources to support these changes. This challenge was compounded by the need for additional training to ensure all staff were adequately prepared to implement the new protocols. Despite these hurdles, the benefits of green practices—particularly in terms of cost savings and environmental impact—were evident, and the hospital management committed to securing the necessary resources for broader implementation in the future.

The integration of green practices into nursing routines has several important implications. First, it demonstrates that sustainable practices can be incorporated into daily nursing activities without compromising patient care. Practices such as waste segregation, energy conservation, and the use of reusable instruments were seamlessly integrated into existing workflows, contributing to both environmental sustainability and cost savings. Furthermore, the results suggest that nurses, as frontline healthcare providers, are well-positioned to lead sustainability efforts. By adopting these green practices, nurses can contribute to reducing the environmental impact of healthcare facilities while simultaneously improving patient care and operational efficiency. The findings from this study support the idea that sustainability in healthcare not only benefits the environment but also enhances the overall quality of care.

### **5. Comparison**

The newly designed green-practice nursing protocols were compared with traditional nursing protocols, which often do not incorporate sustainability considerations. The evaluation highlighted several key differences in both environmental and operational efficiencies. Traditional nursing practices typically rely on disposable medical supplies, lack standardized waste segregation, and do not prioritize energy efficiency in clinical settings. In contrast, the new green-practice protocols focused on reducing waste through recycling and reusing materials, improving energy efficiency with the use of LED lighting and optimized HVAC systems, and adopting more sustainable waste management practices. The environmental impact of the hospital's operations was notably reduced, with an 18% decrease in carbon emissions, demonstrating the effectiveness of integrating sustainability into nursing

practices. Operationally, the hospital also experienced improvements in resource efficiency, reducing waste disposal costs and energy consumption.

The integration of green practices into nursing protocols offers significant long-term benefits, both environmentally and economically. One of the primary advantages is cost savings. By reducing energy consumption, waste disposal fees, and the use of single-use medical supplies, the hospital realized a decrease in operational expenses. In addition to these financial benefits, the hospital's commitment to sustainability improved its image, positioning it as an environmentally responsible institution. This can attract environmentally-conscious patients and staff, further enhancing the hospital's reputation and fostering a culture of sustainability. Moreover, by adopting green practices, the hospital contributed to broader global sustainability goals, such as reducing carbon emissions and supporting eco-friendly healthcare practices, aligning with international environmental standards. Over time, the integration of green practices not only helps reduce the environmental footprint of the healthcare sector but also sets the foundation for a more sustainable healthcare system in the future.

## 6. Conclusion

This study demonstrated that the integration of green practices into nursing protocols led to a significant reduction in the carbon footprint of hospital operations. The findings showed an 18% decrease in carbon emissions, primarily driven by sustainable practices such as waste segregation, the use of reusable medical supplies, and energy-efficient equipment in clinical wards. The pilot phase highlighted the positive impact of green practices on both environmental sustainability and hospital operational efficiency, with notable reductions in energy consumption and waste generation.

This research contributes to the growing body of knowledge on sustainable healthcare practices by providing a practical framework for reducing the environmental impact of hospital care. The successful integration of green practices into nursing protocols not only reduced the hospital's carbon footprint but also demonstrated that sustainability in healthcare can improve operational efficiencies, reduce costs, and enhance the hospital's public image. The findings highlight the potential for nursing staff to play a central role in leading sustainability initiatives within healthcare settings, contributing to a more environmentally responsible and resource-efficient healthcare system.

Future research should focus on refining the green-practice protocols and exploring their application in other areas of healthcare, such as emergency departments, intensive care units, and outpatient settings. Further studies could also evaluate the long-term outcomes of implementing these practices, including sustained reductions in carbon emissions, cost savings, and improvements in staff and patient satisfaction. Additionally, research could examine the scalability of these protocols in different hospital sizes and healthcare systems, ensuring that sustainable practices are accessible and applicable across various healthcare settings. Finally, investigating the broader impact of sustainability on patient outcomes and healthcare quality would provide valuable insights into the holistic benefits of green practices in healthcare.

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