From Vision 2030 to Patient-Safe Green Hospitals: The BRIGHT Green Care Program as a Nursing-Led Conceptual Framework for Sustainable Healthcare in the Gulf Region

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Abstract

Background: Healthcare systems are highly resource-intensive, with hospitals contributing significantly to environmental degradation through excessive energy and water consumption, complex supply chains, and hazardous waste generation. The sector accounts for approximately 4.4% of global net greenhouse gas emissions, surpassing the aviation industry. While international frameworks like the Global Green and Healthy Hospitals (GGHH) network and the NHS Net Zero strategy provide roadmaps for sustainable transformation, initiatives in the Gulf region remain predominantly engineering-focused, lacking integration of clinical, and specifically nursing, leadership. **Aim:** This study aims to present and critically analyze the BRIGHT Green Care Program, a novel, nursing-led conceptual framework designed to systematically integrate environmental sustainability with patient safety protocols in hospitals across the Gulf region, in alignment with the strategic objectives of Saudi Vision 2030**. Methods:** The BRIGHT framework was developed as a conceptual model through a synthesis of international evidence, regional policy analysis, and theoretical structuring. Its architecture incorporates a four-phase implementation timeline (Preparation, Implementation, Expansion, Optimization) and is operationalized through five core domains: Sustainable Medical Supplies; Sustainable Nutrition and Food Safety; Resource Efficiency and Digital Transformation; Circular Economy and Waste Valorization; and Biohazardous and Chemical Waste Management. Each domain is linked to specific, measurable Key Performance Indicators (KPIs), weighted scoring dashboards, and practical evaluation tools, such as an Eco-Friendly IV Set Checklist. **Results:** The framework establishes a scalable, nurse-led model for sustainable healthcare. It positions nursing leadership as the central driver for transforming hospital operations, effectively bridging critical gaps between environmental stewardship and clinical care. The structured approach enables institutions to reduce toxic exposures, enhance resource efficiency, and decrease their environmental footprint, while simultaneously advancing patient safety and aligning with both Saudi Vision 2030 and global sustainability agendas. **Conclusion and Recommendations:** The BRIGHT Green Care Program constitutes the first comprehensive, nursing-led conceptual framework for sustainable healthcare in the Gulf region. It demonstrates that environmental responsibility and patient safety are synergistic goals. Its adoption is recommended to guide hospital policy, procurement, and practice. Further, it is imperative for policymakers to empower nursing leadership in sustainability governance, and for future research to empirically evaluate the framework's impact on clinical, operational, and environmental outcomes across diverse contexts. Widespread adoption can accelerate the transition of Gulf hospitals into safer, greener, and more resilient institutions.

Keywords: Nursing Leadership, Healthcare Sustainability, Conceptual Framework, Patient Safety, Green Hospital, Saudi Vision 2030, Environmental Stewardship

Introduction

Healthcare systems worldwide confront the dual challenge of delivering high-quality patient care while mitigating their substantial environmental footprint. As among the most resource-intensive institutions, hospitals consume vast amounts of energy and water, depend on complex supply chains, and generate significant hazardous and non-hazardous waste. These operations contribute approximately 4.4% of global net greenhouse gas emissions-a share that surpasses that of the aviation sector-and directly exacerbate the climate-related health burdens, such as respiratory and cardiovascular diseases, they are designed to treat **(Eckelman & Sherman, 2016; Health Care Without Harm, 2019; Romanello et al., 2023)**. Consequently, the integration of sustainability into healthcare is increasingly recognized not merely as an environmental objective but as a fundamental imperative for patient safety and public health.

In response to this imperative, robust international frameworks for sustainable healthcare have emerged. Initiatives such as the Global Green and Healthy Hospitals (GGHH) network outline ten comprehensive action areas spanning energy, water, waste, chemicals, and procurement **(Global Green and Healthy Hospitals, 2025).** Accreditation systems like LEED and WELL provide measurable standards for sustainable design and operations. Empirical evidence substantiates the efficacy of these approaches; for instance, the Cleveland Clinic in the United States implemented comprehensive sustainability measures resulting in annual savings exceeding USD 5 million, and later, the UK's National Health Service committed to achieving net-zero emissions by 2040 **(NHS England, 2022).** These examples underscore that environmental stewardship in healthcare yields synergistic benefits, enhancing both financial efficiency and patient well-being.

Within Saudi Arabia and the broader Gulf region, however, the integration of healthcare sustainability remains at a nascent stage. Although national development agendas, notably Saudi Vision 2030, explicitly prioritize environmental stewardship and healthcare transformation, most hospital-based initiatives are predominantly engineering-driven. They focus primarily on infrastructure retrofits, energy efficiency, and water management **(Ministry of Health, Kingdom of Saudi Arabia, 2025).** Reports of clinical or nursing integration into sustainability strategies are scarce, leaving regional hospitals grappling with persistent challenges, including high per-capita energy consumption, water scarcity, and carbon-intensive supply chains. This context highlights a critical need for locally tailored frameworks that bridge clinical practice with environmental management to address the Gulf's unique socio-ecological and healthcare challenges.

Globally, the nursing profession has demonstrated a significant capacity to lead sustainability initiatives, driving progress in areas from perioperative waste reduction to sustainable procurement and patient education **(Alliance of Nurses for Healthy Environments, 2025).** As frontline clinicians, nurses are central to daily decision-making that directly influences resource consumption, waste segregation, and medication safety, positioning them as essential agents of change. Yet, in the Gulf region, the sustainability discourse remains largely confined to managerial and engineering domains. This represents a profound missed opportunity, as empowering nurses in this realm can simultaneously advance environmental performance, strengthen patient safety protocols, and improve overall care quality.

Persistent gaps thus characterize the landscape of sustainable healthcare in the Gulf, namely: (1) the absence of nursing-led conceptual frameworks, (2) a weak integration of clinical practices with environmental sustainability goals, and (3) a limited evaluation of the return on investment for sustainability initiatives in arid, middle-income settings. To address these gaps, this paper presents the BRIGHT Green Care Program, a conceptual nursing-led framework designed to integrate environmental stewardship with patient safety and healthcare transformation. Aligned with the ambitions of Saudi Vision 2030 and international sustainability agendas, the program provides a structured model for Gulf hospitals to evolve into patient-safe, environmentally responsible, and high-performing institutions. The aim of this paper is to present and critically analyze the BRIGHT Green Care Program as a viable framework for advancing sustainable and patient-safe hospital care in the Gulf region.

Background and Rationale

Healthcare systems worldwide represent one of the most resource-intensive sectors, imposing significant environmental burdens that directly compromise public health. The operational footprint of hospitals is substantial, characterized by extensive energy and water consumption, reliance on complex global supply chains, and the generation of considerable hazardous and non-hazardous waste. Current estimates attribute approximately 4.4% of global net greenhouse gas emissions to the healthcare sector, a share that surpasses that of the aviation industry and exacerbates the prevalence of climate-sensitive health conditions, including respiratory and cardiovascular diseases **(Eckelman & Sherman, 2016; Health Care Without Harm, 2019; Romanello et al., 2023).** This interplay underscores that the integration of sustainability into healthcare is not merely an ecological objective but a fundamental component of patient safety and quality care, as environmental degradation and toxic exposures directly undermine the health outcomes the sector is designed to promote.

In recognition of this imperative, international bodies have developed comprehensive frameworks to steer healthcare towards sustainable practices. NHS England has led this transformation with its commitment to achieving a net-zero national health service by 2040 - a pioneering ambition supported by robust, measurable targets and systemic policy integration **(NHS England, 2022).** Subsequently, the Global Green and Healthy Hospitals (GGHH) network established ten interconnected goals targeting energy efficiency, water stewardship, waste management, sustainable procurement, and chemical safety, thereby providing an integrated agenda for health facilities **(Global Green and Healthy Hospitals, 2025).** These initiatives demonstrate that structured sustainability frameworks can yield synergistic benefits, simultaneously reducing environmental impact, realizing cost efficiencies, and advancing patient safety.

Within the Gulf region, the integration of sustainability into healthcare operations remains nascent. While many initiatives have emerged, most remain engineering-driven. For instance, **Al-Kahtani et al. (2022)** highlighted that prevailing hospital-based efforts primarily focus on energy and water conservation, with limited incorporation of clinical practices or nursing leadership. In contrast, Saudi Vision 2030 explicitly emphasizes environmental stewardship as a pillar of its Health Sector Transformation Program, aiming to modernize service delivery while enhancing efficiency and mitigating environmental impact **(Ministry of Health, 2025).** Persistent challenges - including carbon-intensive procurement, high per-capita resource consumption, and regional water scarcity - underscore the critical need for a contextualized framework that effectively bridges overarching sustainability goals with frontline patient care.

Globally, the nursing profession has emerged as a pivotal agent in advancing healthcare sustainability. Campaigns such as the Nurses Climate Challenge have mobilized and educated thousands of nurses in climate and health advocacy, while scholarly work increasingly identifies sustainability as an essential competency within nursing education **(Aronsson et al., 2025; Alliance of Nurses for Healthy Environments, 2025).** Nurses exert direct influence over procurement decisions, waste segregation, medication management, and patient education, positioning them uniquely to embed sustainable principles into daily clinical operations. Nevertheless, in the Gulf context, nursing engagement in sustainability initiatives remains constrained, often relegated to supportive roles within administratively or engineering-led programs, lacking dedicated leadership involvement **(McGain et al., 2020; Breast Cancer Prevention Partners, 2025).**

Despite this global momentum, significant knowledge and practice gaps persist. Firstly, there is a scarcity of nursing-led conceptual frameworks designed to integrate sustainability into healthcare systems specifically within the Gulf region. Secondly, the potential of adopting environmentally preferable medical products, such as those free from DEHP and PVC, is underexplored, despite compelling evidence of their associated health and environmental risks **(Health Care Without Harm, 2023; U.S. Food and Drug Administration, 2025).** Thirdly, the return on investment for green healthcare initiatives has

not been systematically evaluated within middle-income, resource-constrained contexts. Conceptual frameworks in nursing research offer a structured approach to address these gaps, providing the necessary theoretical foundation and pragmatic guidance for implementing innovative care models **(Adom, Hussein, & Agyem, 2018; Flanagan, Beck, & Polit, 2025).**

Significance of the study

In response to these challenges and opportunities, the BRIGHT Green Care Program has been developed as a nursing-led conceptual framework. It is designed to systematically integrate sustainability with patient safety imperatives in the Gulf regional context. By aligning with international best practices while being tailored to the strategic priorities of Vision 2030, this framework seeks to empower nursing leadership, mitigate the environmental footprint of care delivery, and ultimately enhance patient outcomes.

Aim of the Study

This study aims to introduce and critically examine the BRIGHT Green Care Program, a nursing-led conceptual framework developed to integrate the dual imperatives of environmental sustainability and patient safety within Gulf regional healthcare settings. The investigation seeks to elucidate the framework's structure and potential mechanisms for driving systemic change. Furthermore, it will critically evaluate the program's alignment with global sustainability agendas and its capacity to address the distinct socio-environmental challenges and strategic priorities outlined in Saudi Vision 2030, thereby contributing to the evolution of more resilient and responsible healthcare systems in the region.

Objectives of the Framework

The BRIGHT Green Care Program is a nursing-led conceptual framework designed to systematically integrate sustainability imperatives with patient safety protocols within healthcare institutions across the Gulf region. Its primary objective is to establish a structured model that facilitates the transition of hospitals towards environmentally responsible, patient-centered, and high-performance care delivery systems. This initiative directly addresses international mandates for climate-resilient health systems **(Romanello et al., 2023)** and is strategically aligned with the Health Sector Transformation Program under Saudi Vision 2030 **(Ministry of Health, 2025).**

The framework's general aim is to empower and position nursing leadership at the forefront of advancing sustainable healthcare, thereby concurrently reducing the environmental footprint of clinical operations and safeguarding patient health outcomes.

To achieve this aim, the framework is guided by the following specific objectives:

1. To systematically incorporate sustainability principles into core nursing practice. This will be achieved by integrating evidence-based interventions for waste stream reduction, resource conservation, and environmentally conscious clinical decision-making into daily workflows **(Alliance of Nurses for Healthy Environments, 2025; Aronsson et al., 2025).**
2. To augment patient safety through the procurement and utilization of environmentally preferable medical products. A key focus is the advocacy for the substitution of DEHP and PVC-containing supplies with safer alternatives, thereby mitigating patient and environmental exposure to toxicants associated with adverse health effects **(Breast Cancer Prevention Partners, 2025; Health Care Without Harm, 2023; U.S. Food and Drug Administration, 2025).**
3. To optimize resource efficiency in hospital operations. The framework will promote the adoption of best practices in the management of energy, water, and materials, utilizing established global benchmarks such as the Global Green and Healthy Hospitals (GGHH) framework and the NHS Net Zero targets to guide and quantify performance improvements **(Global Green and Healthy Hospitals, 2025; NHS England, 2022; Burch et al., 2021).**
4. To institutionalize robust governance and accountability mechanisms. This involves the establishment of clear, measurable Key

Performance Indicators (KPIs) for sustainability that are congruent with international standards yet sufficiently adaptable to the specific operational and regulatory context of the Gulf region **(Keerthi D Souza et al., 2025; Clarkson et al., 2018)**.

5. To support national and global health agendas. The program ensures alignment of institutional sustainability initiatives with the strategic priorities of Saudi Vision 2030 and the WHO global strategy on digital health, thereby fostering scalability, accountability, and innovation in care delivery **(Ministry of Health, 2025; World Health Organization, 2021; Al-Kahtani et al., 2022).**

Collectively, these objectives establish a foundational blueprint for embedding sustainability as an intrinsic dimension of nursing excellence and healthcare quality. By explicitly linking environmental stewardship with patient safety outcomes, the BRIGHT Green Care Program positions the nursing workforce as central catalytic agents in the transformation of Gulf healthcare institutions into safer, more sustainable, and resilient entities.

Research Questions

To guide the critical analysis of the BRIGHT Green Care Program, this study will address the following research questions:

1. How can the BRIGHT Green Care Program function as a robust, nursing-led conceptual framework to systematically integrate environmental sustainability with patient safety protocols in hospitals across the Gulf region?
2. What specific gaps currently exist in healthcare sustainability practices within the Gulf region that the BRIGHT Green Care Program is designed to mitigate?
3. To what extent does the BRIGHT Green Care Program align with the strategic objectives of Saudi Vision 2030 and established global sustainability frameworks, such as the Global Green and Healthy Hospitals (GGHH) agenda and the NHS Net Zero strategy?
4. What are the concrete roles, responsibilities, and leadership strategies for nurses in championing and operationalizing sustainability initiatives within direct clinical practice?
5. How does the adoption of environmentally preferable practices - including the use of DEHP/PVC-free medical products, digital health technologies, and enhanced waste segregation protocols - correlate with improvements in both patient health outcomes and key environmental performance indicators?

Description of the Framework

The BRIGHT Green Care Program is a conceptual framework, led by the nursing profession, designed to systematically integrate the principles of environmental sustainability with core patient safety objectives within hospital operations. The framework is structured around five synergistic domains, each operationalized through specific, measurable Key Performance Indicators (KPIs). This structure ensures strategic alignment with both global sustainability benchmarks, such as the Global Green and Healthy Hospitals (GGHH) agenda, and the national development goals of Saudi Vision 2030.

1. Sustainable Medical Supplies and Procurement

This domain focuses on mitigating the health and environmental impacts associated with medical products.Its primary initiatives include the systematic transition to DEHP-free and PVC-free intravenous sets and a significant reduction in the procurement of hazardous chemical disinfectants. Key KPIs target a measurable annual increase in the percentage of eco-friendly IV sets procured and a ≥90% reduction in the usage of designated hazardous chemicals. Nurses are instrumental in this domain, acting as advocates for green procurement, auditing product utilization at the unit level, and ensuring adherence to established safety and sustainability protocols. The implementation of this domain directly reduces toxic exposure for both patients and healthcare workers and promotes the development of more sustainable supply chains.

2. Sustainable Nutrition and Food Safety

This domain addresses the significant environmental footprint of hospital nutrition services by integrating food safety with waste reduction.Defined KPIs include the transition to 100% of patient meals being served in non-

plastic and non-polystyrene containers and achieving an ≥80% reduction in single-use plastic cups across facility operations. Nursing staff contribute by overseeing safe meal delivery, educating patients and families on sustainable practices, and monitoring compliance within their clinical units, thereby directly linking daily nutritional care with environmental stewardship.

3. Resource Efficiency and Digital Transformation

Acknowledging the high consumption of energy,water, and materials in healthcare, this domain promotes operational efficiency. KPIs include tracking energy consumption per bed, achieving ≥80% digitalization of administrative and clinical transactions, and ensuring ≥90% proper management of expired materials. This focus aligns with the digital transformation goals of Saudi Vision 2030. Nurses drive this change as primary users and champions of electronic health records, digital clinical documentation, and streamlined, paper-reduced workflows, thereby enhancing both resource conservation and operational resilience.

4. Circular Economy and Waste Valorization

This domain operationalizes circular economy principles by prioritizing the reuse and recycling of hospital materials.Key performance indicators target the reuse of ≥50% of treated wastewater for non-potable purposes such as agriculture, the reuse of ≥60% of carton boxes from procurement shipments, and the reuse of ≥80% of hospital linen. Nurses function as unit-level "green stewards," ensuring correct waste segregation at the source, promoting recycling initiatives, and leading staff awareness campaigns. These activities directly reduce operational costs and bolster institutional resilience against resource scarcity.

5. Biohazardous and Chemical Waste Management

This final domain ensures stringent management and disposal of the most hazardous waste streams,including pharmaceuticals like antibiotics and chemotherapeutic agents. The central KPI mandates 100% compliance with national and international standards for the segregation, handling, and disposal of biohazardous and chemical waste. As frontline clinicians, nurses are critical to the safe execution of these protocols, responsible for the initial segregation of waste, the safe handling of hazardous materials, and the accurate documentation required for regulatory compliance, thereby protecting human health and the environment.

Cross-Cutting Foundation: Nursing Leadership and Governance

The BRIGHT framework is fundamentally underpinned by nursing leadership.Nurses are positioned as "Green Champions" who bridge direct patient care with organizational sustainability governance. Their active involvement spans leading internal audits, monitoring KPI compliance, educating peers, and engaging patients. By embedding sustainability into the fabric of clinical practice, the framework empowers nurses to be central agents in achieving simultaneous improvements in patient safety and environmental performance.

Strategic Alignment

The BRIGHT Green Care Program is explicitly designed to resonate with the sustainability objectives of Saudi Vision 2030,the GGHH network, and the NHS Net Zero strategy. Its distinctive value lies in its clinical, nurse-driven approach, moving beyond traditional engineering-focused solutions. By providing a regionally contextualized and evidence-informed model, the BRIGHT framework offers a viable blueprint for hospitals across the Gulf region in their transition towards becoming high-reliability, patient-safe, and environmentally responsible institutions.

Figure (1): YES Conceptual Diagram of *BRIGHT Green Care* — a nursing-led framework for sustainable healthcare (Developed by the YES Group: Yasmin M. Ayoub, Eman R. Shabib, and Selwan Hamza Elgazzar, 2025).

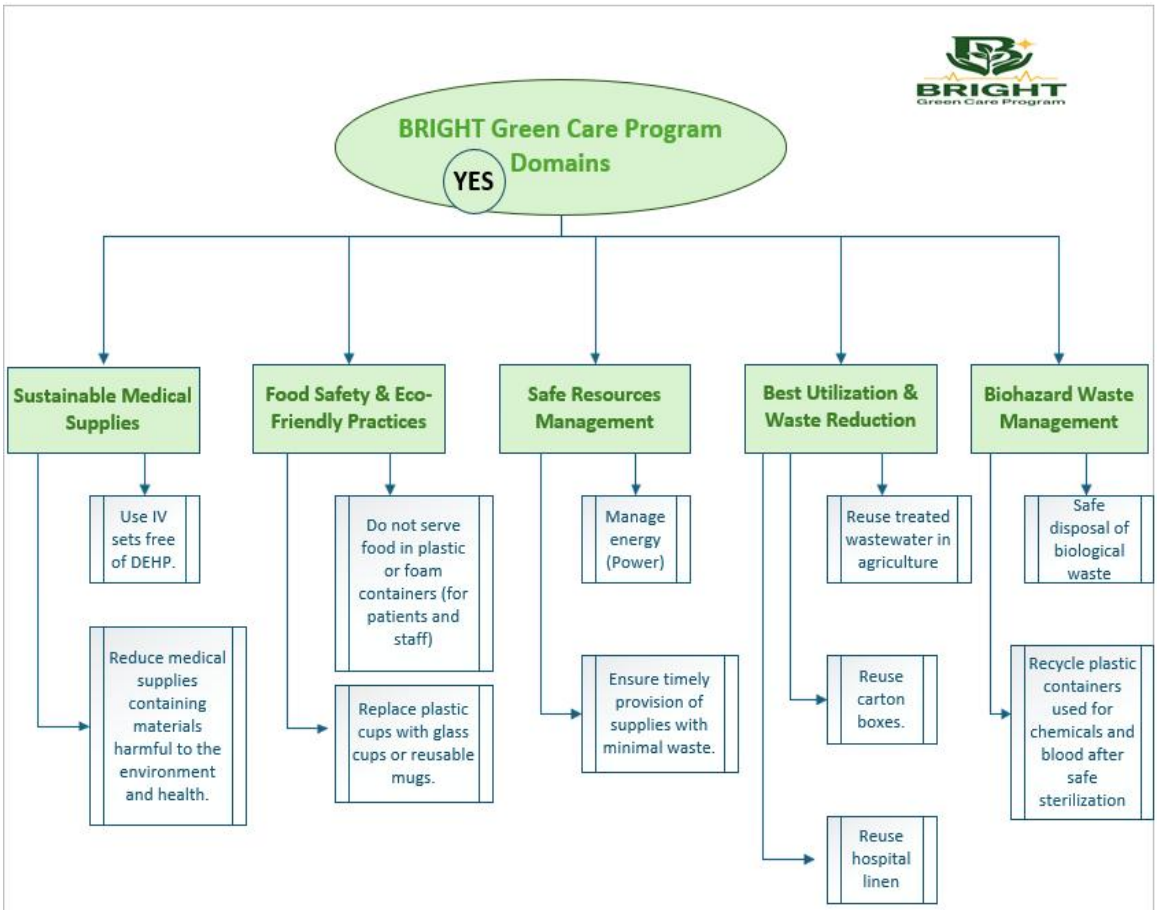

Table (1). Core Domains and Key Performance Indicators (KPIs) of the BRIGHT Green Care Framework

Domain	KPI	Target	Nursing Role	Alignment with Vision 2030
Sustainable Medical Supplies	% of IV sets procured that are DEHP-free, PVC-free	≥ 50%	Nurses participate in product evaluation, advocate for safer IV supplies, and monitor bedside use.	Supports safe medical procurement and patient safety under the Health Sector Transformation Program.
Sustainable Medical Supplies	Reduction in purchase of disinfectants with hazardous materials	≥ 90% within 1 year	Nurses educate staff on safe alternatives and ensure correct handling of eco-friendly disinfectants.	Promotes sustainable procurement and chemical safety.
Food Safety & Eco-Friendly Practices	% of meals served without plastic/foam containers	100%	Nurses supervise patient meals and provide feedback on safe, eco-friendly practices.	Advances waste reduction and health promotion.
Food Safety & Eco-Friendly Practices	% reduction in plastic cup consumption	≥ 80%	Nurses model eco-friendly practices (e.g., using glass or reusable mugs) and educate staff/patients.	Reduces single-use plastic waste in alignment with circular economy goals.
Safe Resources Management	Energy consumption per bed per month (kWh/bed/month)	-15% from baseline	Nurses comply with energy-saving practices (e.g., device shutdown, optimized lighting).	Contributes to Vision 2030 goals on energy efficiency.
Safe Resources Management	% of documentation shifted to paperless (EMR)	≥ 80%	Nurses lead EMR adoption and training for digital documentation.	Aligned with Saudi Digital Health Strategy 2020–2025.
Best Utilization & Waste Reduction	% of treated wastewater reused in agriculture	≥ 85%	Nurses support water conservation practices and patient/family education.	Strengthens water stewardship, a Vision 2030 priority.
Best Utilization & Waste Reduction	% of carton boxes reused	≥ 60%	Nurses collaborate in safe segregation and recycling initiatives.	Promotes sustainable supply chain management.
Best Utilization & Waste Reduction	% of hospital linen reused	≥ 80%	Nurses ensure proper handling of hospital linen to reduce waste.	Improves efficiency and reduces operational costs.
Biohazard Waste Management	% of biohazard waste disposed according to safety standards (e.g., antibiotic, chemotherapy waste)	100%	Nurses perform accurate waste segregation, labeling, and monitoring.	Enhances infection control and environmental safety.
Biohazard Waste Management	% of plastic chemical waste safely sterilized and reused/disposed	100%	Nurses oversee compliance with biohazard protocols and educate junior staff.	Protects community health and ensures compliance with safety standards.

Study Design

This study employs a conceptual framework design, a recognized methodological approach in theoretical research aimed at advancing scientific knowledge through the clarification of constructs, integration of multidisciplinary evidence, and development of structured models to guide practice, education, and policy **(Adom, Hussein, & Agyem, 2018; Flanagan, Beck, & Polit, 2025).** Accordingly, the BRIGHT Green Care Program presented herein constitutes a systematically developed conceptual framework rather than an empirical implementation study. Its purpose is to theoretically integrate the principles of environmental sustainability with patient safety protocols under a nursing leadership model.

Justification for the Design

The selection of this design is justified by identified critical gaps within the Gulf regional context. While international systems, such as the Global Green and Healthy Hospitals (2025) agenda and the NHS Net Zero framework **(NHS England, 2022),** offer comprehensive models for sustainable healthcare, their regional application has largely been confined to engineering-centric solutions, with minimal integration of clinical, and specifically nursing, leadership **(Ministry of Health, 2025; Romanello et al., 2023).** This omission persists despite robust global evidence underscoring the pivotal role of nursing in championing waste reduction, safe procurement, and patient advocacy **(Alliance of Nurses for Healthy Environments, 2025; Aronsson et al., 2025).**

Objectives of the Conceptual Framework

The conceptual framework methodology was thus deployed to achieve the following objectives:

1. Synthesize extant international and regional literature on green healthcare initiatives.
2. Identify specific gaps in the integration of sustainability within nursing practice in the Gulf context.
3. Translate global sustainability benchmarks into a set of locally relevant domains and measurable Key Performance Indicators (KPIs).
4. Structure a practical, nurse-led model explicitly aligned with the strategic priorities of Saudi Vision 2030.

Theoretical Foundation

By adopting this conceptual approach, the study establishes a foundational theoretical basis for subsequent empirical investigations, including implementation science research, program evaluation, and outcome measurement. As noted by Clarkson et al. (2018), conceptual frameworks function as "system maps" that delineate the relationships between complex inputs and outcomes, while the evidence-based design literature affirms that well-articulated models are instrumental in accelerating both research uptake and practical transformation (Ulrich et al., 2008).

Conclusion

In conclusion, the BRIGHT Green Care Program is presented as a rigorously developed, nursing-led conceptual framework that merges theoretical robustness with practical applicability. Its design posits sustainability not as a peripheral environmental concern, but as an intrinsic component of safe, high-quality, and resilient healthcare delivery in the Gulf region. This aligns with methodological recommendations that conceptual frameworks serve as precursors to empirical studies, enabling structured inquiry, knowledge translation, and policy formulation (Adom et al., 2018).

Program Framework

The BRIGHT Green Care Program was conceptualized as a structured, multi-phase framework designed to systematically integrate environmental sustainability with patient safety protocols within hospital operations. Conceived as a nurse-led, evidence-informed initiative, the program is strategically aligned with both national development agendas and global sustainability imperatives. The framework is operationalized through four sequential phases spanning a three-year period, incorporating measurable indicators and robust monitoring mechanisms to ensure accountability, evaluative rigor, and scalability.

Framework Phases

Phase 1: Preparation and Baseline Assessment (Months 1–3)

This inaugural phase focuses on establishing foundational governance and evaluative benchmarks. Key activities include the formation of a multidisciplinary Sustainability Steering Committee with nursing leadership, conducting a comprehensive

baseline assessment of environmental performance across critical domains (e.g., supplies, nutrition services, resource consumption, waste streams), the definitive specification of Key Performance Indicators (KPIs), and the strategic allocation of necessary resources, budgets, and training infrastructure.

· **Phase 2 – Core Implementation and Capacity Building (Months 4–12)**

The second phase centers on the initial rollout of interventions and organizational capacity development. This involves launching institution-wide awareness campaigns and competency-based training sessions led by nurse educators, initiating "quick-win" projects such as the installation of LED lighting, implementation of waste segregation systems, and deployment of water-saving devices, and activating digital monitoring systems for tracking resource use (energy, water) and waste generation.

Phase 3: Systemic Expansion and Integration (Year 2)

The third phase is characterized by the scaling and deeper integration of sustainable practices. Efforts expand to include the adoption of renewable energy solutions (e.g., solar panels, smart climate controls), the hospital-wide formalization of recycling programs and environmentally preferable procurement policies, and the execution of cross-departmental sustainability audits with direct nursing involvement to assess adherence and identify opportunities for improvement.

Phase 4: Optimization and Institutionalization (Year 3)

The final phase is dedicated to performance optimization and securing external validation. This entails a comprehensive evaluation of outcomes against pre-defined KPI targets, the refinement and scaling of successful initiatives while addressing performance gaps, and systematic preparatio`n for national and international green hospital accreditation. The phase culminates in the public dissemination of an annual sustainability report to ensure transparency and facilitate benchmarking.

Framework Components

1. Governance and Nursing Leadership: The framework institutionalizes a governance structure that centralizes the role of nurses in coordinating, implementing, and auditing sustainability initiatives, thereby embedding green practices into the core of clinical care delivery.
2. Monitoring and Evaluation Tools: A suite of evaluative instruments supports the framework, including:
   - A comprehensive KPI Framework.
   - A Weighted KPI Dashboard for performance scoring.
   - An Integrated Benchmarking and Risk Management Dashboard.
   - An Eco-Friendly IV Set Evaluation Checklist.
3. Underlying Principles:

Patient Safety Primacy: All environmental interventions are contingent upon upholding and enhancing clinical safety, medication integrity, and the reduction of patient and staff exposure to toxins.

Strategic Alignment: The program is explicitly designed to support the objectives of Saudi Vision 2030, the Saudi Green Initiative, and relevant World Health Organization frameworks.

Scalability and Replicability: The framework is constructed for hospital-wide application and is readily adaptable for deployment across other healthcare facilities within a regional cluster or network.

Expected Outcomes

The systematic implementation of the BRIGHT Green Care Program is projected to generate significant, multi-level outcomes across clinical, organizational, and policy domains, establishing a new paradigm for sustainable healthcare in the region.

At the clinical level, the program is anticipated to substantially enhance patient safety by systematically reducing exposure to hazardous substances. This will be achieved through the targeted substitution of DEHP and PVC-containing medical devices, thereby mitigating the documented risks of toxicant leaching **(U.S. Food and Drug Administration, 2025; Health Care Without Harm, 2023).** Concurrently, improvements in waste segregation and biohazard management protocols are expected to reduce cross-contamination and infection risks, directly safeguarding both patients and healthcare workers.

At the organizational level, the framework is projected to drive measurable gains in operational efficiency and environmental performance. The structured KPIs are designed to yield a marked

decrease in energy and water consumption per bed, a significant reduction in the volume of non-hazardous waste sent to landfill, and an increase in recycling and resource reuse rates. These efficiencies are expected to translate into long-term cost savings and a strengthened return on investment **(McGain et al., 2020),** while simultaneously preparing institutions for successful accreditation under emerging national and international green hospital standards.

At the policy and systemic level, the program is positioned to catalyze a strategic shift by formally establishing nursing leadership as indispensable to healthcare sustainability. By providing a validated, scalable model, it offers a practical blueprint for operationalizing the environmental stewardship goals of Saudi Vision 2030 and the Saudi Green Initiative **(Ministry of Health, 2025).** The successful demonstration of this nurse-led framework is expected to influence regional policy, encouraging the integration of similar models into health sector transformation programs and establishing a replicable benchmark for sustainable care delivery across the Gulf Cooperation Council (GCC) states.

Collectively, the BRIGHT Green Care Program is expected to demonstrate that the integration of environmental sustainability is not merely an operational upgrade but a fundamental component of high-quality, resilient, and ethically responsible healthcare.

Ethical and Political Considerations

The development of the BRIGHT Green Care Program, as a conceptual framework study, did not involve human subject recruitment, primary data collection, or clinical interventions. Therefore, formal Institutional Review Board (IRB) approval was not requisite. Nonetheless, the research process adhered rigorously to established principles of ethical scholarship, maintaining commitments to transparency, intellectual integrity, and systematic evidence synthesis throughout all developmental stages **(Flanagan, Beck, & Polit, 2025; Adom, Hussein, & Agyem, 2018).**

From an ethical perspective, the framework is fundamentally anchored in the principle of patient safety primacy. All proposed sustainability interventions—including the phased substitution of DEHP- and PVC-laden medical devices, the systematic enhancement of biohazard waste management, and the integration of digital health solutions—are explicitly contingent upon their capacity to safeguard medication integrity, minimize toxicological exposures, and protect the well-being of patients and healthcare personnel **(Health Care Without Harm, 2023; U.S. Food and Drug Administration, 2025).** This precautionary, safety-first approach ensures that environmental objectives do not compromise clinical care standards but rather reinforce them.

Politically, the program demonstrates strategic alignment with Saudi Arabia's national development agenda, explicitly supporting the health sector transformation goals and environmental stewardship targets outlined in Saudi Vision 2030 and the Saudi Green Initiative **(Ministry of Health, 2025).** By positioning sustainability as a core component of healthcare modernization, the framework resonates with national priorities for economic diversification, public health resilience, and environmental conservation. Furthermore, it interfaces seamlessly with global policy frameworks, including the World Health Organization's strategy for climate-resilient health systems and the action agenda of the Global Green and Healthy Hospitals network, thereby situating the Gulf region within broader transnational efforts for sustainable health system reform (Global Green and Healthy Hospitals, 2025; World Health Organization, 2021).

By centering nursing leadership within its governance structure, the BRIGHT Green Care Program addresses both ethical imperatives for patient protection and political mandates for workforce development and systemic innovation. This integrated approach advances a replicable model of healthcare that is clinically safe, environmentally responsible, and strategically aligned with evolving policy expectations at national and international levels

lts and Application in Practice

The operationalization of the BRIGHT Green Care Program is demonstrated through a series of structured implementation tools and comparative analyses, which collectively translate the conceptual framework into actionable practice.

Table 2 delineates the phased implementation timeline spanning a three-year period. This structured progression—commencing with foundational governance establishment and baseline assessment, advancing through targeted intervention deployment, and culminating in optimization and accreditation readiness—ensures methodological feasibility and enables

continuous performance monitoring across all hospital operational units.

Table 3 presents the comprehensive Key Performance Indicator (KPI) framework, which operationalizes the program's sustainability objectives into quantifiable metrics across its five core domains. Each KPI is explicitly defined with a corresponding calculation formula, baseline measurement, performance target, and compliance criteria. This rigorous specification ensures that sustainability practices are not only measurable but are directly correlated with enhancements in patient safety and healthcare quality standards.

Table 4 illustrates the weighted KPI dashboard, a strategic management tool that assigns relative priority scores to each domain based on its projected impact on both patient safety and environmental sustainability. This prioritization mechanism enables hospital administrators to allocate financial, human, and technical resources strategically, focusing efforts on high-impact areas such as energy consumption reduction, wastewater reuse, and the procurement of safer medical supplies.

Table 5 provides a comparative analysis of nursing-led sustainability initiatives in global versus Gulf regional contexts. The comparison reveals that while international examples underscore the transformative potential of nurses in reducing waste, mitigating emissions, and eliminating hazardous materials, initiatives within the Gulf region remain predominantly engineering-led, with notably limited engagement of nursing leadership. This identified disparity highlights both the critical gap in current regional practice and the distinctive contribution of the BRIGHT Green Care Program.

Table 6 outlines the integrated benchmarking and risk management dashboard, which aligns the program's KPIs with international benchmarks, projects financial implications, and proposes corresponding mitigation strategies. The analysis demonstrates that certain interventions, such as the transition to DEHP-free intravenous supplies, may necessitate higher initial investment but yield substantial long-term returns through operational savings, regulatory compliance, and most importantly, enhanced patient safety outcomes.

Table 7 introduces the Eco-Friendly IV Set Evaluation Checklist, a practical, nursing-led tool designed to inform and guide procurement decisions. This instrument synthesizes environmental impact, pharmacological safety, and clinical regulatory criteria, thereby ensuring that selected medical products concurrently satisfy international safety standards and advance institutional sustainability policies.

Application in practice

Table (2). Implementation Timeline of the BRIGHT Green Care Program (Year 1–Year 3)

Phase	Timeline	Key Activities
Phase 1 – Preparation	Months 1–3	- Form the Sustainability Committee. - Conduct baseline environmental performance assessment. - Define KPIs and data collection methods. - Allocate budget and resources.
Phase 2 – Initial Implementation	Months 4–12	- Launch staff awareness and training programs. - Implement quick-win projects (LED lighting, waste segregation, water-saving devices). - Introduce digital tracking systems for energy, water, and waste.
Phase 3 – Expansion	Year 2	- Integrate renewable energy solutions (solar panels, smart climate controls). - Expand recycling and green procurement policies hospital-wide. - Begin cross-departmental sustainability audits.
Phase 4 – Optimization & Accreditation	Year 3	- Evaluate outcomes against KPIs. - Address gaps and scale successful initiatives. - Prepare for national and international green hospital accreditation. - Publish the hospital's annual sustainability report.

Table 3. Comprehensive KPI Framework of the BRIGHT Green Care Program (Year 1–3)

Domain	Indicator (KPI)	Formula	Baseline	Target	Current Performance	Data Collection / Method	Data Analysis / Compliance Levels
Sustainable Medical Supplies	% of IV sets procured that are DEHP-free, PVC-free	(Actual total score ÷ 14) × 100	XX% (Month/Year)	≥ 64%	XX% (Month/Year)	Eco-friendly checklist (Appendix 1)	≥85% = Highly Compliant; 64% = Moderate; <64% = Not compliant
Sustainable Medical Supplies	Reduction in purchase of disinfectant with hazardous materials	(Baseline – Current ÷ Baseline) × 100	XX%	≥ 90% within 1 year	XX% (Month/Year)	Pharmacy / Procurement logs	% reduction from baseline
Food Safety & Eco-Friendly Practices	% of meals served without plastic/foam containers	(Meals w/o plastic ÷ Total meals) × 100	XX% (Month/Year)	100%	XX% (Month/Year)	Kitchen & Catering logs	Simple ratio compliance
Food Safety & Eco-Friendly Practices	% consumption of plastic cups	(Plastic cups dispensed ÷ Total cups) × 100	XX% (Month/Year)	≥ 80%	XX% (Month/Year)	Store issue records	≥80% = Highly compliant; 65–79% = Moderate; <65% = Not compliant
Safe Resources Management	Energy consumption per bed per month (kWh/bed/month)	Total kWh ÷ Beds ÷ Months	XX kWh/bed/month	-15% from baseline	XX kWh/bed/month (Month/Year)	Energy meters & facility reports	Trend analysis (before vs. after)
Safe Resources Management	% of Go to Paperless (Digital Transactions)	(Digital ÷ Total) × 100	XX% (Month/Year)	≥ 80%	XX% (Month/Year)	HIS/EMR/ERP monthly reports	≥80% = Highly compliant; 65–79% = Moderate; <65% = Not compliant
Best Utilization & Waste Reduction	% of Returned Expired Waste	(Expired waste returned ÷ Total expired waste) × 100	XX% (Month/Year)	≥ 90%	XX% (Month/Year)	Pharmacy / Store disposal records	Compliance with MOH policy
Best Utilization & Waste Reduction	% of Carton Boxes Reused	(Carton boxes reused ÷ Total carton boxes) × 100	XX% (Month/Year)	≥ 60%	XX% (Month/Year)	Housekeeping / Waste mgmt. logs	Simple compliance ratio
Best Utilization & Waste Reduction	% of Hospital Linen Reused	(Linen reused ÷ Total discarded linen) × 100	XX% (Month/Year)	≥ 80%	XX% (Month/Year)	Laundry service reports	Trend analysis
Biohazard Waste Management	% of Biohazard Waste Disposed According to Safety Standards (Antibiotic & Chemotherapy)	(Disposal compliant ÷ Total biohazard waste) × 100	XX% (Month/Year)	100%	XX% (Month/Year)	Infection Control & Safety logs	Method: Collection → Temporary Storage → Autoclaving/incineration → Licensed transport → Final disposal
Biohazard Waste Management	% of Plastic Chemical Waste Disposed According to Safety Standards	(Disposal compliant ÷ Total plastic chemical waste) × 100	XX% (Month/Year)	100%	XX% (Month/Year)	Hazardous waste tracking system	Segregation → Collection → Temp. Storage → Transport → Certified Disposal

Table (4). Sustainability KPI Dashboard with Weighted Indicators for the BRIGHT Green Care Program

Domain	KPI	Target	Weight %
Sustainable Medical Supplies	% of IV sets procured that are DEHP-free, PVC-free	≥ ….%	8%
	Reduction in purchase of disinfectant with hazardous materials	≥ 90% within 1 year	8%
Food Safety & Eco-Friendly Practices	% of meals served without plastic/foam containers	100%	8%
	% consumption of plastic cup	≥ 80%	8%
Safe Resources Management	Energy consumption per bed per month (kWh/bed/month)	-15% from baseline	10%
	% of go to paperless	≥ 80%	8%
	% return expired waste	90%	8%
Best Utilization & Waste Reduction	% of treated wastewater reused in agriculture	≥ 50%	10%
	% of carton boxes reused	≥ 60%	8%
	% of hospital linen reused	≥ 80%	8%
Biohazard Waste Management	% of biohazard waste disposed according to safety standards (antibiotic & chemotherapy)	100%	8%
	% of plastic chemical waste disposed according to safety standards	100%	8%
TOTAL			100%

Note: Weights were assigned based on relative priority and impact on patient safety and environmental sustainability as determined by the authors.

Table (5). Comparison of Nursing-Led Green Initiatives Globally and in the Gulf Region

Level	Initiative / Hospital	Nursing Role	Scope	Outcomes	References
Global – USA & Europe	Nurses Climate Challenge	Nurses trained thousands of peers on climate-health links, reducing waste and plastics	100+ hospitals and nursing schools	Wide awareness, integration of sustainability into nursing education & practice	Alliance of Nurses for Healthy Environments, 2025; Aronsson et al., 2025
Global – UK (NHS)	Green Nursing Challenge (2023–2025)	Nursing teams led low-carbon practices, replacing harmful supplies with eco-friendly alternatives	NHS hospitals	Embedded nursing in national sustainability plan, operational policy change	NHS England, 2022; Global Green and Healthy Hospitals, 2025
Global – USA (Cleveland Clinic)	Greening the OR – Nurse-Led	OR nurses implemented recycling of surgical tools, reduced anesthetic gas emissions	Operating Rooms	Significant reduction in gas emissions, millions in cost savings	Thomas et al., 2022; McGain et al., 2020
Global – USA (Kaiser Permanente)	Nurses for Waste Reduction	Nursing teams led waste segregation campaigns, trained clinical teams	Nursing units & clinical departments	Reduced medical waste, improved compliance, cost savings	Health Care Without Harm, 2019; Lee et al., 2002
Global – UK (University Hospitals Bristol)	Pediatric Nursing Green Practices	Pediatric and NICU nurses reused linen, reduced plastic use	Pediatric & NICU wards	Reduced waste, improved patient environment	Ulrich et al., 2008; Burch et al., 2021
UAE / Saudi Arabia / GCC	No published nursing-led green initiatives (mostly admin/engineering-driven)	Nursing involved as implementers, not leaders	Energy, water, infrastructure projects	Efficiency improvements but no nursing-led sustainability framework	Ministry of Health, 2025; Al-Kahtani et al., 2022

Note. This table compares global and regional nursing-led sustainability initiatives. It highlights the gap in the GCC region where nursing leadership in sustainability frameworks is limited compared to international contexts.

Table (6). Integrated Dashboard for BRIGHT Green Care KPIs, Benchmarks, and Risk Management

Domain	KPI (Indicator)	Global / Regional Benchmark	Target (BRIGHT Program)	Financial Impact (Cost/Saving)	Risk	Mitigation Plan
Sustainable Medical Supplies	% of IV sets procured DEHP/PVC-free	Kaiser Permanente (USA): 100% transition to DEHP-free IV sets (BCPP, 2024)	≥ 64% (Year 1), ≥ 90% (Year 3)	+15–20% higher cost/unit, long-term ROI via reduced complications	Supply chain limitations	Partner with GCC procurement networks, phased implementation
Food Safety & Eco-Friendly Practices	% of meals served without plastic/foam containers	Hospitals: Food waste ≈ 15% of total waste (EPA, 2017)	100% plastic-free meals	Initial cost for reusable containers, long-term savings from reduced disposables	Staff resistance	Nursing-led awareness, "Green Champions" program
Food Safety & Eco-Friendly Practices	Food waste reduction	EPA: 15% hospital waste from food	≤ 5% food waste	Savings ~10% procurement	Resistance in segregation	Regular monitoring, staff training
Safe Resources Management	Energy consumption per bed per month	US average ~738.5 kWh/m²/year (ENERGY STAR, 2021)	-15% from baseline	LED, HVAC optimization: ROI 3–5 years	High capital cost	Government subsidies, phased retrofitting
Safe Resources Management	% of go to paperless (digital transactions)	WHO: Global Digital Strategy (2021)	≥ 80%	Saves printing costs, efficiency gain	Weak monitoring	Digital dashboard, HIS integration
Best Utilization & Waste Reduction	% of treated wastewater reused	Global 20%, Israel 40% reuse	≥ 50% reuse	Saves 30% of water bills	Project delays	Pilot projects, early engineering involvement
Best Utilization & Waste Reduction	% of linen reused	Best hospitals: >80%	≥ 80%	10–15% procurement savings	Staff compliance	Clear SOPs, audits
Biohazard Waste Management	% of biohazard waste disposed safely	WHO: 100% compliance required	100%	Compliance avoids penalties	Improper segregation	Automation (RFID/barcodes), audits
Biohazard Waste Management	% of plastic chemical waste disposed safely	WHO/EPA standards	100%	Avoids accreditation risks	Non-compliance	Nursing audits, certified disposal contractors

Table (7) . Eco-Friendly IV Set Evaluation Checklist

Purpose: To assess the environmental and pharmacological safety of intravenous infusion sets (IV Sets) in alignment with patient safety, medication integrity, and Green Hospital standards.

No	Criterion	Met (1)	Not Met (0) / Comments
1	DEHP-free tubing and components		
2	PVC-free materials		
3	Made of biocompatible materials		
4	No drug sorption or leaching (e.g., for chemotherapy or insulin)		
5	Certified ISO compliant (e.g., ISO 8536, ISO 594)		
6	CE-marked or FDA-approved		
7	Sterilized using ETO or Gamma (non-toxic methods)		
8	Includes micron filter (≤15 µm)		
9	Latex-free		
10	Non-pyrogenic (safe for infusion)		
11	Clearly labeled as eco-friendly or green product		
12	Safe disposal instructions provided (eco-conscious)		
13	Supported by regulatory guidance (FDA, WHO, SCENIHR, etc.)		
14	Supported by published evidence or clinical studies		

Scoring system

Score Range	Rating	Interpretation
12–14 points	Highly Compliant	Environmentally safe and recommended
9–11 points	Moderately Compliant	Acceptable, but with room for improvement
< 9 points	Non-Compliant	Not suitable for eco-safe clinical use

Evaluator Name: _____
Date of Evaluation: _____
Department/Unit: _____

Discussion

This study positions the BRIGHT Green Care Program as an innovative, nursing-led conceptual framework that integrates sustainability principles with patient safety protocols within hospital operations. By employing a phased implementation model, measurable Key Performance Indicators (KPIs), and structured nursing governance, the framework directly addresses persistent gaps in Gulf healthcare systems - namely the underutilization of nursing leadership in sustainability initiatives, the dominance of fragmented engineering-centric approaches, and the absence of contextually tailored benchmarks for sustainable healthcare delivery.

The phased implementation timeline (Table 2) reflects a systematic and deliberate strategy consistent with established international models such as the NHS England Net Zero roadmap, which advocates for sequential, evaluable interventions to ensure systemic readiness and long-term viability **(NHS England, 2022).** In contrast to the Gulf region's prevailing infrastructure-focused sustainability efforts **(Ministry of Health, 2025),** this four-phase model advances a clinically engaged pathway by embedding sustainability into governance, training, and accreditation. Critically, the explicit integration of nurses as central actors in governance and auditing provides a transformative departure from traditional practice, aligning with calls for systemic, nurse-led leadership in healthcare transformation **(Clarkson et al., 2018).**

The KPI framework (Table 3) is central to translating sustainability goals into auditable and operational metrics. This design resonates with global procurement standards such as ISO 20400, which emphasize traceability and accountability as essential pillars of sustainable practice **(Keerthi D Souza et al., 2025).** Importantly, the BRIGHT framework contributes a novel dual focus that links environmental objectives-such as eliminating DEHP/PVC medical devices -with direct improvements in patient safety outcomes **(Health Care Without Harm, 2023; U.S. Food and Drug Administration, 2025).** Such integration remains largely absent in regional contexts, where procurement processes are rarely evaluated for clinical implications, thus limiting opportunities to align environmental stewardship with care quality.

The weighted KPI dashboard (Table 4) provides a strategic mechanism for prioritizing interventions based on projected impact. This aligns with evidence from hospital energy management systems, where targeted prioritization enhances both resource efficiency and patient safety outcomes **(Burch et al., 2021).** Within the Gulf, emphasis on wastewater reuse is particularly relevant given regional water scarcity, and evidence suggests reclaimed water strategies can provide substantial ecological and operational benefits **(Akiyode et al., 2023).** By integrating these priorities into a weighted framework, the BRIGHT Program establishes a scalable model for balancing sustainability investments with clinical risk reduction.

The comparative analysis of nursing-led initiatives (Table 5) reveals a critical paradigm gap. Internationally, initiatives such as the Nurses Climate Challenge underscore the profession's capacity to act as innovators and leaders in climate advocacy **(Alliance of Nurses for Healthy Environments, 2025).** In the Gulf region, however, sustainability initiatives remain largely confined to technical and engineering domains, with limited engagement of frontline clinicians. This is a missed opportunity, as sustainability is increasingly recognized as an essential nursing competency, integral to both education and practice **(Aronsson et al., 2025).** By architecturally embedding nurses at the core of sustainability governance, the BRIGHT framework repositions them as pivotal agents in shaping environmentally responsible clinical care.

The integrated benchmarking and risk management dashboard (Table 6) further strengthens the framework's applicability by aligning local targets with international benchmarks. For instance, Kaiser Permanente's complete transition to DEHP-free IV systems exemplifies the feasibility and long-term value of sustainable procurement **(Breast Cancer Prevention Partners, 2025).** While upfront investments may appear substantial, evidence consistently demonstrates that sustainable procurement reduces waste disposal costs, improves energy efficiency, and mitigates compliance risks (McGain et al., 2020; Lee et al., 2002). By embedding phased procurement and financial safeguards, the framework ensures congruence with the dual goals of healthcare modernization and economic diversification outlined in Saudi Vision 2030 **(Ministry of Health, 2025).**

Finally, the Eco-Friendly IV Set Evaluation Checklist (Table 7) operationalizes the program's principles through a practical, nurse-led tool for procurement decisions. By integrating environmental, regulatory, and pharmacological safety criteria, the checklist reflects WHO and FDA priorities for safe and sustainable device use **(World Health Organization, 2021; U.S. Food and Drug Administration, 2025).** Its distinctive contribution lies in empowering nurses as key actors in procurement, thereby ensuring that products meet both patient safety and environmental criteria. This redefined role directly responds to international calls for nurse-led leadership in building climate-resilient health systems **(Alliance of Nurses for Healthy Environments, 2025).**

In summary, the BRIGHT Green Care Program transcends traditional sustainability frameworks by situating nursing leadership as a central driver of systemic transformation. It synthesizes global best practices with regional priorities, providing a scalable, evidence-informed model that bridges environmental stewardship with patient safety. Future research should focus on empirical testing of the

framework, evaluating its feasibility in practice, and identifying contextual facilitators and barriers to implementation across Gulf healthcare systems.

Conclusion

This study has presented a critical analysis of the BRIGHT Green Care Program, establishing it as a pioneering, nurse-led conceptual framework designed to integrate environmental sustainability with patient safety within Gulf regional healthcare institutions.

The analysis confirms, first, that the BRIGHT framework functions as a robust and theoretically grounded model. It systematically bridges the often-separated domains of sustainability and clinical governance through its structured components: measurable Key Performance Indicators (KPIs), a strategic weighted dashboard for resource prioritization, and practical, nursing-led evaluation tools. Its fundamental design proactively positions nursing leadership as the central operational driver for system-wide change, thereby moving beyond the limitations of fragmented, engineering-centric approaches that have historically dominated regional efforts.

Second, this examination has elucidated critical contextual gaps within the Gulf healthcare sustainability landscape. The findings reveal that existing initiatives have predominantly focused on infrastructure efficiency, with minimal systematic involvement of clinical staff—particularly nurses—in leading, auditing, and innovating sustainability practices. The BRIGHT framework directly addresses this gap by architecturally embedding nurses into the core of governance structures, procurement committees, and risk management strategies, thereby activating a largely untapped resource for sustainable transformation.

Third, the framework demonstrates rigorous alignment with both the strategic national objectives of Saudi Vision 2030 and established global sustainability models, including the Global Green and Healthy Hospitals (GGHH) agenda and the NHS Net Zero strategy. Its phased implementation timeline and benchmark-driven design effectively operationalize international best practices, while its specific domains and KPIs ensure contextual relevance and applicability within the Gulf's unique healthcare and environmental setting.

Fourth, the program explicitly redefines and expands the professional role of nurses, characterizing them not merely as implementers but as essential leaders, educators, auditors, and patient advocates for safe and sustainable care. This enhanced role not only elevates the profession's visibility and impact but also ensures that the principles of sustainability are consistently applied and evaluated within daily clinical practice.

Finally, the study underscores that the adoption of environmentally preferable practices—such as the procurement of DEHP/PVC-free medical supplies, the advancement of digitalization to curtail resource use, and the stringent segregation of biohazardous waste—is directly correlated with tangible enhancements in patient safety. These include reduced toxic exposures, strengthened infection prevention protocols, and measurable gains in operational efficiency concerning energy and resource consumption.

In summary, the BRIGHT Green Care Program provides a replicable, evidence-informed, and nurse-led blueprint for advancing sustainable healthcare in the Gulf region and analogous contexts. It conclusively demonstrates that environmental stewardship and patient safety are not competing priorities but are intrinsically synergistic. Furthermore, it affirms that empowered nursing leadership is an indispensable catalyst for achieving health systems that are simultaneously high-quality, resilient, and ethically responsible for both human and planetary health.

Recommendations

Derived from the comprehensive analysis of the BRIGHT Green Care Program, the following actionable recommendations are proposed to facilitate the integration of sustainability into healthcare systems across the Gulf region:

For Hospital and Clinical Practice

1. Institutionalize the Framework: Systematically integrate the BRIGHT Green Care Program

across all clinical and non-clinical departments. This requires the formal adoption of its structured Key Performance Indicators (KPIs) and monitoring dashboards into existing hospital governance and quality assurance systems.

2. Prioritize Sustainable Procurement: Mandate the use of the Eco-Friendly IV Set Evaluation Checklist and similar tools to guide the procurement of DEHP/PVC-free medical devices and other environmentally preferable supplies. This strategy directly mitigates patient and staff exposure to hazardous substances while fostering a greener supply chain.

3. Optimize Resource Management: Strengthen and standardize protocols for waste segregation, recycling, and resource reuse. Focus on high-impact areas such as linen reuse, carton box recycling, and the application of treated wastewater for non-potable purposes to significantly reduce the institution's environmental footprint and operational expenditures.

For Nursing Leadership and Professional Development

1. Empower Nurses as Change Agents: Formalize and expand the role of nurses beyond direct patient care to include responsibilities in sustainability auditing, staff education, procurement evaluation, and organizational policy advocacy. This positions them as central drivers and accountable leaders in the green healthcare transformation.

2. Integrate Sustainability into Education: Embed core principles of environmental sustainability and planetary health into ongoing nursing education, competency frameworks, and professional development curricula. This ensures the nursing workforce possesses the necessary knowledge and skills to align clinical practice with stewardship objectives.

3. Establish a "Green Champion" Network: Develop and support a formal cadre of "Green Nurse Champions" within each clinical unit. These champions would be tasked with leading local awareness initiatives, monitoring compliance with sustainability protocols, mentoring peers, and serving as a liaison to hospital-wide sustainability committees.

For Policy and Strategic Governance

1. Align with National Visions: Actively ensure that hospital-level sustainability strategies are explicitly and demonstrably aligned with the overarching goals of national frameworks such as Saudi Vision 2030 and the Saudi Green Initiative, thereby securing institutional buy-in and aligning with national transformation agendas.

2. Foster Regional Collaboration: Promote collaboration at the Gulf Cooperation Council (GCC) level to establish regional procurement networks for sustainable medical products. This collective approach can improve purchasing power, standardize green criteria, and reduce dependency on hazardous materials across the region.

3. Advocate for Accreditation Standards: Engage with national and international accreditation bodies, including the CBAHI and JCI, to incorporate nurse-led sustainability frameworks and specific environmental performance indicators into their accreditation standards. This would formally recognize sustainability as an integral component of healthcare quality and patient safety.

For Future Research and Innovation

1. Conduct Empirical Implementation Research: Undertake rigorous quantitative and qualitative studies to empirically evaluate the BRIGHT framework's impact on key outcomes, including patient safety indicators, cost-benefit ratios, and specific environmental performance metrics (e.g., carbon footprint, waste diversion rates).

2. Explore Digital Enablers: Investigate the role of digital health innovations, such as advanced Electronic Medical Record (EMR) functionalities and dedicated Health Information System (HIS) dashboards, in automating the tracking of sustainability KPIs and enhancing real-time performance evaluation.

3. Benchmark Regional Performance: Initiate comparative studies that benchmark the progress and outcomes of Gulf-based sustainability initiatives against global leaders in green healthcare. Such research

can identify transferable best practices and inform the continuous refinement of regional models

Limitations

While this study presents a comprehensive conceptual framework, several limitations warrant acknowledgment to contextualize the findings and guide future research.

1. Conceptual Nature of the Framework: The BRIGHT Green Care Program is presented as a conceptual model developed through synthesis and theoretical structuring. As such, the projected outcomes and feasibility are derived from literature and logical extrapolation rather than empirical measurement. The absence of implementation data from a live clinical setting means that the practical efficacy and unforeseen challenges remain to be validated.
2. Contextual Specificity: The framework was intentionally designed to address the specific policy, environmental, and healthcare contexts of the Gulf region, particularly Saudi Arabia. While its core principles are universally applicable, certain elements—such as its direct alignment with Saudi Vision 2030 and the Saudi Green Initiative—may require significant adaptation for direct transferability to other geographic or healthcare systems with different regulatory and cultural landscapes.
3. Dependence on Secondary Data Sources: The development and analysis relied exclusively on secondary sources, including international sustainability reports, peer-reviewed literature, and policy documents. Although this provides a robust theoretical foundation, it introduces a limitation common to conceptual research: the inability to ground-truth assumptions, KPIs, and implementation barriers through primary data collection in operational hospital environments.
4. Evolving Policy and Technological Landscape: The field of healthcare sustainability is dynamic, with rapid advancements in green technologies, evolving international accreditation standards, and shifting national policies. Consequently, specific benchmarks and technological recommendations included in the framework may require periodic revision to maintain alignment with best practices and regulatory requirements.
5. Unquantified Implementation Barriers: The framework identifies potential risks and mitigation strategies based on published evidence. However, the scale and nature of real-world barriers—such as initial capital investment requirements, resistance to change among staff, variability in supply chain reliability for green products, and the need for sustained senior leadership commitment—can only be fully assessed and quantified through practical application. Acknowledgment

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