

Fostering Sustainability in Healthcare: The Role of Green Transformational Leadership in Shaping Nurses' Green Behavior and Advancing

Green Hospital Practices -A narrative review

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Abstract

Background: Healthcare systems contribute significantly to environmental degradation through high energy use, medical waste, and reliance on toxic materials, posing a challenge to align patient safety with sustainability. While frameworks such as WHO's climate-resilient health systems provide strategic direction, operational pathways for frontline implementation remain underdeveloped. **Aim:** This study explores the role of Green Transformational Leadership (GTL) in shaping nurses' green behavior and advancing Green Hospital outcomes, with the aim of proposing an integrated framework that bridges global sustainability goals and daily clinical practice. **Design:** A narrative review approach was applied, synthesizing evidence from peer-reviewed literature, WHO technical guidance, and recent empirical studies (2010–2025). Sources were analyzed thematically across domains of leadership, workforce engagement, hospital sustainability standards, and governance mechanisms. **Results:** The findings confirm that GTL plays a decisive role in motivating nurses—who represent nearly 70% of the hospital workforce—to adopt eco-friendly practices such as waste segregation, energy and water conservation, and the use of safer materials. Nurses' green behavior acts as a mediating factor, translating leadership vision into measurable environmental performance. These behaviors, when reinforced by hospital-wide sustainability policies and procurement practices, contribute directly to achieving **Green Hospital standards** (e.g., WHO and GGHH benchmarks). The analysis also identifies barriers such as funding gaps and weak governance, alongside enablers like training, strong leadership, and regulatory alignment. **Conclusion:** This study highlights GTL as the pivotal link between leadership vision, nurses' daily practices, and systemic sustainability outcomes. By embedding environmental stewardship within nursing leadership, the proposed framework offers a novel, nurse-centered pathway to operationalize the Green Hospital model. **Contribution:** Unlike prior studies focusing only on policies or infrastructure, this research uniquely demonstrates how leadership-driven nursing behavior can transform sustainability from abstract goals into institutionalized practice, providing a replicable roadmap for healthcare systems worldwide.

Keywords: Green Transformational Leadership (GTL), Nurses' Green Behavior, Green Hospital, and Sustainable Healthcare.

Introduction

The healthcare sector is a vital component of modern societies, yet it is also a significant contributor to environmental degradation through high energy consumption, excessive water use, and the generation of large volumes of medical waste. In recent years, the growing concerns about climate change, global warming, and resource depletion have placed increasing pressure on healthcare organizations to adopt sustainable practices that minimize their ecological footprint. This has led to the emergence of the Green Hospital concept—a healthcare facility that integrates environmental

responsibility into its infrastructure, operations, procurement, and clinical practices to reduce ecological harm while maintaining patient safety and quality of care (Khairunnisa et al, 2022; Al Fannah et al, 2023; Wang et al., 2025).

In this transformation, nurses play a pivotal role. As the largest group within the hospital workforce, they directly influence environmental performance through their daily practices in resource utilization, waste segregation, patient education, and clinical decision-making. Their actions—whether conserving materials, choosing eco-friendly options, or following proper waste protocols—are critical to operationalizing sustainability

policies at the bedside. Despite evidence that nurses generally hold positive attitudes toward environmental stewardship, research shows a persistent gap between environmental awareness and the consistent adoption of green behaviors. Bridging this gap is essential for achieving the goals of a Green Hospital, where environmental sustainability becomes an integral component of healthcare delivery (Li et al., 2021; Khairunnisa et al, 2022; Wang et al., 2025).

Within this context, leadership has emerged as a crucial driver of organizational change toward sustainability. Transformational leadership, a style grounded in inspiring and motivating followers to transcend their self-interests for a collective purpose, has proven effective in fostering innovation and commitment across various sectors. When applied to environmental objectives, this style is referred to as Green Transformational Leadership (GTL) (Burns 1978; Bass 1990).

Transformational leadership, as initially described by Burns (1978) and later expanded by Bass (1990), is characterized by four key dimensions—idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration—through which leaders inspire followers to transcend self-interest and work toward shared organizational goals. Building on this foundation, Green Transformational Leadership (GTL) embeds environmental values and sustainability goals into the transformational leadership framework, thereby aligning leadership influence with ecological objectives (Al-Ghazali et al., 2022; Elsafty, 2025). In the GTL model, idealized influence manifests in leaders acting as role models for environmentally

responsible behavior; inspirational motivation involves articulating a compelling green vision; intellectual stimulation encourages innovative solutions to environmental challenges; and individualized consideration focuses on mentoring staff to develop and implement green practices (Wang et al., 2025).

In healthcare settings, GTL is increasingly recognized as a critical driver for sustainability-oriented change. Empirical evidence from nursing contexts indicates that GTL enhances environmental awareness, strengthens staff commitment to sustainability, and promotes green creativity among nurses. Importantly, GTL bridges the gap between hospital-level sustainability policies and bedside practices, ensuring that environmental strategies are translated into daily clinical routines. Despite these benefits, research on GTL in healthcare—particularly in nursing—is still limited, with most existing studies focusing on corporate or educational sectors. This underscores the need for further exploration of how GTL can shape nurses' green behavior in clinical environments (Li et al., 2021; Suliman et al; 2023; Torun, 2023; Moustafa et al., 2024).

Nurses' Green Behavior

Nurses' green behavior refers to voluntary and organizationally encouraged actions taken by nurses to minimize environmental harm and promote sustainability in clinical practice. These behaviors include proper waste segregation and recycling, energy and water conservation during patient care, the use of environmentally friendly materials, and active participation in hospital-led sustainability programs. As the largest professional group within healthcare organizations, nurses' environmental practices directly influence a hospital's

ecological footprint (Li et al., 2021; Othman et al., 2025).

Studies indicate that leadership style, organizational support, and empowerment are among the strongest predictors of nurses' green behavior (Wang et al., 2025). When guided by leaders who embody GTL, nurses are more likely to integrate sustainability principles into their daily clinical decision-making. GTL fosters an enabling environment by increasing environmental awareness, shaping a shared organizational identity around sustainability, and encouraging creative problem-solving to reduce environmental impact (Li et al., 2021; Balouch et al., 2023). However, despite nurses' generally positive attitudes toward environmental stewardship, there remains a documented gap between awareness and consistent adoption of green behaviors, often due to workload pressures, lack of resources, and insufficient institutional reinforcement (Torun, 2023; Elkholy, 2024).

Green Hospital

The concept of the Green Hospital reflects a healthcare facility's commitment to minimizing its environmental footprint while maintaining or improving patient care quality. Guided by frameworks such as the World Health Organization's *Climate Resilient and Environmentally Sustainable Health Care Facilities* (WHO, 2020) and the Global Green and Healthy Hospitals (GGHH, 2020) agenda, Green Hospitals pursue sustainability across domains including energy efficiency, water conservation, waste reduction, safer materials management, and sustainable procurement (GGHH, 2023; WHO, 2023). These initiatives require both technical and behavioral changes, emphasizing that environmental sustainability is not solely an

infrastructural challenge but also a cultural and organizational one.

Nurses, as the largest segment of the healthcare workforce, are pivotal to operationalizing Green Hospital initiatives. Their green behaviors—shaped and reinforced by GTL—serve as the primary mechanism through which hospital sustainability policies translate into measurable outcomes, such as reduced waste volumes, lower energy use, and safer materials adoption (Li et al., 2021; Wang et al., 2025). In this sense, GTL provides the leadership climate, nurses' green behavior represents the operational pathway, and the Green Hospital serves as the strategic outcome.

Interrelationship of the Three Concepts

The integration of GTL, nurses' green behavior, and the Green Hospital model presents a coherent framework for advancing environmental sustainability in healthcare. GTL sets the vision and fosters the organizational culture necessary for sustainability; nurses' green behavior operationalizes this vision through daily practice; and the Green Hospital model provides the strategic structure within which these efforts are coordinated and measured. This triadic relationship not only aligns leadership and frontline practice with global sustainability goals but also addresses the pressing need for environmentally responsible healthcare systems in the face of climate change and resource scarcity (Kurnaz, 2025).

Despite international policy momentum, the empirical literature linking these three variables in nursing contexts remains sparse, particularly in low- and middle-income countries and the Arab region. This gap highlights the need for research that examines how GTL can be leveraged to enhance nurses' green behavior and accelerate the transition toward Green

Hospital standards (Yanhong & Rafiq, 2024).

Theoretical Framework

This study is grounded in **Transformational Leadership Theory** (Burns, 1978; Bass, 1990) and the Theory of Planned Behavior (Ajzen, 1991), integrated within the sustainability-focused concept of the **Green Hospital** model (WHO, 2020; GGHH, 2020).

Transformational Leadership Theory posits that leaders inspire followers to achieve beyond expectations by appealing to higher values, fostering innovation, and creating a sense of shared purpose. Within the environmental sustainability context, this leadership style evolves into **Green Transformational Leadership (GTL)**—a model in which the four core components of transformational leadership (idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration) are reframed toward ecological objectives (Al-Ghazali et al., 2022; Wang et al., 2025). GTL leaders act as role models for environmentally responsible behavior, articulate a compelling vision for a sustainable workplace, challenge existing practices through green innovation, and support staff in adopting environmentally friendly initiatives.

The Theory of Planned Behavior (TPB) provides a behavioral lens for understanding how GTL can influence nurses' green behavior. TPB suggests that individuals' actions are shaped by three determinants: attitude toward the behavior, subjective norms, and perceived behavioral control (Ajzen, 1991). In the context of nursing, GTL can positively shape these determinants by:

1. Enhancing nurses' attitudes toward sustainability through environmental education and value alignment.
2. Creating strong subjective norms by embedding sustainability into organizational culture.
3. Increasing perceived behavioral control by providing resources, training, and empowerment to act sustainably.

The **Green Hospital** model serves as the overarching institutional framework within which GTL and nurses' green behavior operate. A Green Hospital is defined as a healthcare facility that minimizes its environmental footprint across domains such as energy efficiency, waste reduction, water conservation, and sustainable procurement, without compromising patient care quality (WHO, 2020; GGHH, 2020). Achieving Green Hospital standards requires alignment between leadership vision and frontline practices—making nurses' green behavior the operational link between strategic environmental policies and measurable ecological outcomes.

In this framework, GTL acts as the enabling factor, nurses' green behavior represents the mediating mechanism, and Green Hospital performance is the desired organizational outcome. The model assumes that effective GTL will foster positive environmental attitudes, strong social norms, and increased capability among nurses, thereby enhancing their green behavior. In turn, the cumulative impact of these behaviors contributes to the realization of Green Hospital objectives.

This theoretical integration addresses the gap in sustainability research within nursing contexts by combining leadership theory, behavioral psychology, and institutional sustainability frameworks

into a unified model. It positions GTL as a critical leadership approach for bridging the policy-practice gap and accelerating the transition toward environmentally

environmental practices. When both elements operate in synergy, they create a reinforcing cycle: leadership inspires action, action validates leadership, and

Conceptual model linking Green Transformational Leadership, Nurses' Green Behavior, and Green Hospital outcomes



responsible healthcare systems.

Figure 1. Conceptual model linking Green Transformational Leadership, Nurses' Green Behavior, and Green Hospital outcomes.

The successful realization of the Green Hospital vision hinges on the effective alignment of leadership strategies with frontline clinical behaviors. **Green Transformational Leadership** provides the strategic impetus—offering vision, motivation, and the capacity to dismantle cultural and structural barriers to sustainability—while **nurses' green behavior** translates these leadership directives into tangible, day-to-day

both together strengthen the organizational culture of sustainability.

This dynamic is particularly critical in healthcare settings, where environmental goals must coexist with uncompromising clinical quality and patient safety standards. In such environments, GTL not only fosters the **awareness** and **commitment** necessary for green behavior but also empowers nurses to exercise green creativity—finding innovative ways to reduce waste, optimize resource use, and integrate eco-conscious practices into routine care. Over time, these behaviors contribute directly to the hospital's environmental performance metrics, supporting its progression toward

Green Hospital certification or equivalent recognition. By examining how GTL shapes nurses' green behavior, this review addresses a critical intersection of leadership theory, environmental sustainability, and nursing practice—one that holds the potential to redefine both the cultural and operational pathways toward sustainable healthcare.

Despite the growing global emphasis on sustainable healthcare, current literature reveals significant gaps in operationalizing environmental sustainability within clinical settings. Existing studies have often focused on high-level policies or technical infrastructure, while the leadership–behavior–hospital sustainability nexus remains underexplored. In particular, the mediating role of nurses—who represent the largest workforce in healthcare—has not been sufficiently examined in relation to sustainability outcomes.

This study contributes to filling these gaps by proposing an integrated framework that links Green Transformational Leadership (GTL) to nurses' green behavior, and subsequently to Green Hospital outcomes. By situating nurses at the center of sustainability implementation, the study demonstrates how daily practices such as waste segregation, energy and water conservation, safe material use, and patient education can translate leadership vision into measurable environmental performance.

Furthermore, the framework introduces measurable indicators and KPIs aligned with WHO and GGHH standards, thereby providing hospitals with practical tools for monitoring progress. This alignment bridges the gap between policy-level aspirations and frontline operational reality, ensuring that sustainability is not only a strategic goal but also an embedded

component of nursing practice and hospital culture.

Significance of the Study

The pursuit of environmental sustainability in healthcare has become a strategic necessity worldwide. Hospitals are highly resource-intensive, consuming large amounts of energy and water while producing substantial waste. Globally, healthcare facilities can generate up to 29 pounds of waste per bed per day, a significant portion of which is hazardous and non-biodegradable (**Wang et al., 2025**). In Saudi Arabia, medical waste generation rates have been estimated at 2.45–3.4 kg per patient per day, highlighting the urgent need for systematic environmental management in clinical settings (**Sobaih et al., 2022**).

The **Green Hospital** concept, as defined by the World Health Organization, refers to healthcare facilities that minimize environmental impact through efficient resource use, pollution prevention, and sustainable operational practices—while maintaining high-quality patient care. Achieving Green Hospital status requires a coordinated approach that integrates leadership commitment, staff engagement, and policy alignment.

In this regard, Green Transformational Leadership (GTL) is essential because it provides the leadership vision and motivational drive to embed sustainability into the organizational culture. Leaders practicing GTL articulate a compelling green vision, act as role models for eco-friendly practices, stimulate creative problem-solving for environmental challenges, and provide individualized support to staff engaging in green initiatives (**Al-Ghazali et al., 2022; Balouch et al., 2023**). Empirical evidence shows that targeted GTL interventions can increase staff participation in

sustainability activities by **up to 25%** (Moustafa et al., 2024). In the context of Green Hospitals, GTL ensures that sustainability objectives are not just formal policies but are actively integrated into daily operations.

Equally critical is Nurses' Green Behavior, which encompasses everyday environmentally responsible actions such as proper waste segregation, water and energy conservation, and the use of eco-friendly materials (Li et al., 2021; Awan et al., 2023). Nurses, who represent 60–70% of the healthcare workforce, are the primary agents translating sustainability strategies into operational reality. Despite high levels of environmental awareness, studies indicate that less than **40%** of nurses consistently participate in structured green initiatives (Wang et al., 2025), indicating a gap between knowledge and practice. Strengthening nurses' green behavior is therefore a direct pathway toward achieving measurable Green Hospital outcomes.

By highlighting the interdependence between leadership and frontline behavior, this study emphasizes that achieving a Green Hospital is not merely about technology or infrastructure upgrades—it is fundamentally about cultivating an organizational culture in which environmental responsibility is embedded in every clinical and administrative decision.

Aim of the Study

This narrative review aims to critically examine the relationship between Green Transformational Leadership (GTL) and nurses' green behavior, highlighting the underexplored role of leadership in shaping environmental responsibility within healthcare settings.

Objectives of the Study

1. **To evaluate** the relationship between Green Transformational Leadership (GTL) and nurses' green behavior in hospital settings.
2. **To examine** the influence of GTL on mediating factors including environmental awareness, environmental commitment, and green organizational identity among nurses.
3. **To determine** the extent to which these mediating factors contribute to enhancing nurses' engagement in environmentally responsible practices.
4. **To explore** how the interplay between GTL and nurses' green behavior can facilitate the transformation of healthcare facilities into Green Hospitals.
5. **To provide** practical recommendations for hospital administrators, nurse leaders, and policymakers to integrate environmental sustainability into leadership development programs and organizational policies.

Research Questions

1. How does Green Transformational Leadership (GTL) influence nurses' green behavior in healthcare settings?
2. To what extent do mediating factors—such as environmental awareness, environmental commitment, green creativity, and green organizational identity—explain the relationship between GTL and nurses' green behavior?
3. What specific leadership behaviors and strategies within the GTL framework are most effective in promoting environmentally responsible practices among nurses?

4. How does the integration of GTL and nurses' green behavior contribute to the development of Green Hospitals?
5. Are there contextual or organizational factors within healthcare institutions that strengthen or weaken the impact of GTL on nurses' green behavior?
2. Dimensions and behavioral markers of GTL in healthcare settings
3. Patterns and determinants of nurses' green behavior
4. Mediating mechanisms linking GTL to environmental performance (e.g., awareness, commitment, creativity, organizational identity)
5. Organizational and policy implications for achieving Green Hospital status

Research Design

This study employed a narrative review design, selected for its capacity to integrate diverse sources of evidence across leadership theory, environmental sustainability, healthcare management, and nursing practice. Unlike systematic reviews that apply narrow inclusion criteria and focus solely on quantifiable outcomes, the narrative approach allows for thematic synthesis and critical interpretation of heterogeneous literature—including theoretical models, empirical research, organizational reports, and professional guidelines (Tenny et al, 2017).

This design was particularly suited to the study's aim: to explore the relationship between Green Transformational Leadership (GTL) and nurses' green behavior, and to examine how leadership-driven initiatives can accelerate the adoption of the Green Hospital concept. The review incorporates peer-reviewed articles, global and regional policy documents (e.g., WHO sustainability frameworks, national green healthcare strategies), and case studies published between 2010 and 2024.

Evidence was synthesized thematically and narratively, with focus on five core domains:

1. Conceptual foundations and evolution of transformational leadership into GTL

This qualitative structure enabled the review to contextualize fragmented findings, identify theoretical and practical gaps, and propose actionable leadership- and nursing-driven recommendations for embedding environmental stewardship into the operational and cultural fabric of healthcare organizations.

Setting of the Study

As a narrative review, this study was conducted through an integrative and conceptual lens, without primary data collection. The scope of the literature reviewed spans international and regional contexts, with particular emphasis on sustainability frameworks, leadership approaches, and nursing practices relevant to environmentally responsible healthcare. While theoretical models and empirical findings were drawn from global scholarly sources indexed in databases such as PubMed, Scopus, and Web of Science, the analysis gives special consideration to healthcare systems where structured environmental policies are still emerging, and the adoption of the Green Hospital concept is in its developmental stages.

The review situates itself firmly within the nursing domain, focusing on leadership influence, behavioral change, and professional engagement in sustainability initiatives. The practical implications and interpretive perspective are aligned with

hospital-based nursing practice in high-impact clinical areas—including intensive care units, oncology departments, and surgical wards—where resource consumption and waste generation are significant, making the role of Green Transformational Leadership and nurses' green behavior critical to environmental performance improvement.

Subjects of the Study

As a narrative review, this study did not involve human participants or primary data collection. Instead, the “subjects” refer to the thematic units of analysis derived from the reviewed literature. These include:

1. Green Transformational Leadership (GTL) models and frameworks, particularly those applied in healthcare and nursing contexts.
2. Nurses' green behavior as documented in empirical studies, including environmentally responsible clinical practices such as waste segregation, energy and water conservation, and the use of eco-friendly materials.
3. Mediating mechanisms linking GTL to green behavior—specifically environmental awareness, environmental commitment, green creativity, and green organizational identity.
4. Healthcare organizations implementing sustainability initiatives, with a focus on policies, leadership strategies, and cultural factors that support the Green Hospital concept.

These thematic areas were indirectly examined through analysis of peer-reviewed articles, organizational reports, policy documents, and leadership and

sustainability literature published between 2010 and 2025.

Tool of Data Collection

As a narrative review, this study did not utilize standardized data collection instruments such as surveys, questionnaires, or observation checklists. Instead, data were collected through a structured search and selection of relevant literature, policy documents, and organizational reports related to Green Transformational Leadership (GTL), nurses' green behavior, and the Green Hospital concept.

The data collection process relied on the following tools:

1. Electronic Databases

Peer-reviewed literature was identified through major academic databases, including PubMed, ScienceDirect, Scopus, Web of Science, and Google Scholar, using targeted search queries.

2. Search Terms / Keywords

- Keywords and Boolean combinations included:
 - “Green Transformational Leadership”
 - “Nurses' green behavior”
 - “Green Hospital”
 - “Leadership and sustainability in healthcare”
 - “Environmental awareness in nursing”
 - “Healthcare environmental performance”
 - “Environmental commitment in hospitals”

3. Grey Literature and Official Reports

Grey literature and professional guidelines were retrieved from credible global and regional sources, including:

- World Health Organization (WHO)
 - sustainability and green healthcare frameworks

- Health Care Without Harm (HCWH) – sustainable healthcare case studies
- United Nations Environment Programme (UNEP) – environmental sustainability reports
- National and regional healthcare authorities – hospital sustainability strategies and policy guidelines 2023

4. Inclusion Period

Only documents published between 2010 and 2025 were considered to ensure coverage of both historical context and the most recent developments in GTL and nurses' green behavior research.

Inclusion and Exclusion Criteria

To ensure the relevance, credibility, and alignment of the reviewed literature with the scope of the study, the following criteria were applied:

Inclusion Criteria

1. Articles, reports, and policy documents published between **2010 and 2025**, addressing GTL, nurses' green behavior, or sustainability in healthcare.
2. Peer-reviewed scientific publications, conceptual papers, empirical studies, and organizational reports.
3. Narrative reviews, position papers, and case studies discussing leadership influence on sustainability in clinical practice.
4. Studies and reports focusing on:
 - Dimensions and applications of GTL in healthcare
 - Behavioral patterns and determinants of nurses' green behavior
 - Mediating mechanisms (environmental awareness,

commitment, creativity, organizational identity)

- Implementation of the Green Hospital concept

5. Publications in English to ensure clarity of interpretation and ease of cross-referencing.

Exclusion Criteria

1. Studies unrelated to leadership or green behavior in healthcare settings.
2. Publications that do not address environmental sustainability, leadership influence, or nursing practice.
3. Editorials, blog posts, advertisements, or non-scientific opinion pieces lacking evidence-based content.
4. Non-English publications without official English translations.
5. Studies focused exclusively on non-healthcare industries or leadership in unrelated fields.

Only sources meeting the inclusion criteria were critically analyzed and integrated into the thematic synthesis. All selected literature was reviewed for relevance to the core themes of leadership, sustainability, nursing practice, and the organizational transformation toward Green Hospitals.

Instrument Validity and Reliability

As this study is a narrative review, no primary data collection instruments (e.g., questionnaires or clinical observation tools) were used. However, the validity and reliability of the review process were ensured through the following methodological safeguards:

Validity Assurance

- Only sources from peer-reviewed journals, internationally recognized organizations (e.g., World Health Organization, Health

Care Without Harm, United Nations Environment Programme) and reputable healthcare institutions were included.

- Documents were evaluated for relevance to the study aims, focusing on content that directly addressed Green Transformational Leadership (GTL), nurses' green behavior, and the Green Hospital concept.
- Emphasis was placed on triangulating evidence from multiple disciplines—leadership theory, sustainability science, and nursing practice—to ensure comprehensive coverage of the topic.

Reliability Assurance

- The literature search strategy was systematically applied across multiple databases (PubMed, Scopus, Web of Science, Google Scholar) using consistent keywords and predefined inclusion criteria.
- Source selection and thematic analysis were cross-validated by comparing recurring patterns and findings across different studies to ensure consistency in interpretation.
- Only official documents, policy frameworks, and verified academic publications from 2010 to 2025 were analyzed, reducing the risk of outdated or non-representative evidence.
- Although no statistical reliability coefficients (e.g., Cronbach's alpha) were applicable, the trustworthiness of the review was strengthened through rigorous source verification, methodological transparency, and

thematic saturation in the collected evidence

Ethical Research Considerations

This study is a narrative review of published literature and did not involve human participants, patient data, or animal experimentation. Therefore, formal ethical approval from an institutional review board (IRB) was not required.

Nonetheless, all ethical research principles were upheld by:

- Ensuring accurate citation of all sources, including peer-reviewed articles, organizational reports, and policy documents related to Green Transformational Leadership (GTL), nurses' green behavior, and the Green Hospital concept.
- Relying solely on publicly available data and verified scientific publications to ensure transparency and credibility.
- Avoiding any fabrication, falsification, or misrepresentation of evidence in the synthesis and discussion of findings.
- Respecting intellectual property rights and adhering to ethical standards in academic writing and publication.

The study aligns with established ethical guidelines for scholarly research, ensuring integrity, transparency, and accountability in disseminating scientific knowledge, and promoting responsible use of evidence to support leadership and sustainability initiatives in healthcare.

Field Work

No field work was conducted for this study, as it is based on a narrative review methodology involving the synthesis of existing literature, policy documents, and organizational reports. The study did not include direct observation, surveys,

interviews, or clinical data collection from hospital settings.

Instead, the review critically analyzed published research, leadership frameworks, sustainability guidelines, and grey literature related to Green Transformational Leadership (GTL), nurses' green behavior, and the Green Hospital concept. This analysis incorporated diverse healthcare contexts, with a focus on hospital environments where environmental performance and leadership-driven initiatives intersect—such as intensive care units, oncology wards, and surgical departments, where resource use and waste generation are substantial.

The review reflects the realities of nursing leadership, frontline clinical practice, and sustainability implementation in hospital environments, but it does so through indirect analysis of documented evidence rather than through primary field engagement.

The Administrative Design Included

This narrative review was conducted independently by the researcher, without the involvement of any field team or external collaborators. The entire administrative and scientific process was self-managed, and included the following steps:

1. The researcher personally designed the study structure, formulated the research questions, and identified the scope and key thematic domains of the review, focusing on Green Transformational Leadership (GTL), nurses' green behavior, and the Green Hospital concept.
2. A systematic search for relevant literature was conducted using major academic databases, including: Google Scholar,

PubMed, Scopus, and Web of Science

The researcher utilized well-defined keywords related to leadership, sustainability, environmental awareness, green creativity, organizational identity, and nursing environmental practices.

3. All references were carefully selected by the researcher after manual screening and critical appraisal to ensure alignment with the study's aim, inclusion criteria, and thematic focus.
4. The review process included: Documentation of search strategies, Verification of source credibility, and Extraction of content related to leadership influence, behavioral change in nursing, and organizational sustainability practices
5. The researcher maintained full responsibility for all stages of the study—from conceptualization and literature selection to thematic synthesis and manuscript preparation—in accordance with accepted academic and ethical standards.

Statistical Analysis

As this study was conducted using a narrative review design, no statistical analysis was performed. The review did not involve the collection of quantitative data, numerical outcomes, or the application of inferential statistics.

Instead, the analysis was conducted using a qualitative thematic synthesis approach, whereby findings from diverse sources—including peer-reviewed studies, organizational reports, sustainability frameworks, and nursing leadership

literature—were extracted, categorized, and interpreted across five main domains:

1. Conceptual foundations and evolution of Green Transformational Leadership (GTL)
2. Dimensions and behavioral markers of GTL in healthcare settings
3. Patterns and determinants of nurses' green behavior
4. Mediating mechanisms linking GTL to environmental performance (e.g., environmental awareness, environmental commitment, green creativity, organizational identity)

5. Organizational and policy implications for achieving the Green Hospital concept

This interpretive process allowed the researcher to identify recurring patterns, theoretical gaps, and practical opportunities for integrating sustainability into nursing leadership and clinical practice, without relying on statistical modeling.

All sources were reviewed for thematic relevance, cross-verified against each other, and synthesized to construct a coherent, evidence-based narrative focused on leadership-driven sustainability and nursing impact.

Results

Table 1: Comparative Dimensions of Leadership Style vs. Green Leadership Style (WHO, 2020).

Dimension	Traditional Leadership Style	Green Leadership Style
Vision	Focus on organizational goals	Focus on sustainable and eco-friendly vision
Motivation	Drive performance outcomes	Drive both performance and environmental responsibility
Influence	Role modeling based on efficiency	Role modeling environmentally responsible behaviors
Decision-making	Centered on productivity	Integrates ecological and social impacts

Table2 : Leadership Styles and Their Impact on Green Behavior in Healthcare (Bass (1990); WHO (2020); Li et al. (2021); Al-Ghazali et al. (2022); Torun (2023); Wang et al. (2025)).

Leadership Style	Definition	Focus	Mechanism of Influence	Strengths	Limitations	Impact on Nurses' Green Behavior
Autocratic	Leader makes unilateral decisions with minimal staff input	Control, compliance	Command-and-control; rules enforcement	Fast decision-making in crises	Low staff engagement; resistance	Minimal – short-term compliance only
Democratic	Leader involves staff in decision-making	Participation, collaboration	Collective discussion; shared decision	Builds trust, morale	Time-consuming; potential conflicts	Moderate – engagement improves, but sustainability may lack consistency
Transactional	Based on reward and punishment	Performance, compliance	Exchange-based: incentives vs. penalties	Clear structure; measurable outputs	Limits innovation; dependent on rewards	Moderate – green actions tied to rewards, low intrinsic motivation
Transformational	Inspires followers to transcend self-interest for shared vision	Motivation, innovation	Role modeling; intellectual stimulation	Fosters creativity and commitment	May lack explicit environmental focus	High – long-term engagement, but indirect ecological impact
Green Transformational Leadership (GTL)	Embeds sustainability into transformational leadership	Sustainability, eco-friendly change	Inspires, models, empowers green practices	Strongest alignment with sustainability; systemic change	Requires governance & culture to institutionalize	Very high – systemic adoption of green practices, embedded in hospital culture

Figure 2. Dimensions of Green Transformational Leadership

DIMENSIONS OF GREEN TRANSFORMATIONAL LEADERSHIP

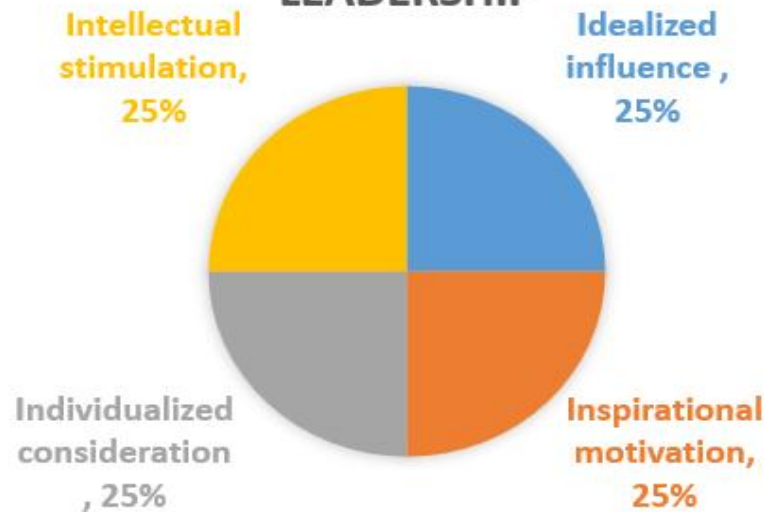


Table 3. Integration of Green Leadership, Green Behavior, and Green Hospital Outcomes

Dimension	Green Leadership (GTL)	Nurses' Green Behavior	Green Hospital Outcomes
Vision & Role Modeling	Leaders articulate sustainability vision and model eco-friendly practices	Nurses adopt behaviors aligned with role models (e.g., waste segregation, DEHP-free use)	Hospital policies reflect sustainability vision; improved environmental reputation
Motivation & Commitment	Leaders inspire commitment to ecological goals	Nurses conserve resources, actively engage in hospital initiatives	Reduced energy/water use, improved compliance with WHO/GGHH
Innovation & Problem-Solving	Leaders encourage creativity to address environmental challenges	Nurses innovate daily practices (e.g., energy-saving, patient green education)	Hospital achieves measurable performance improvements (↓ carbon footprint, ↓ costs)
Individualized Support	Leaders mentor and empower staff to take initiative	Nurses sustain green practices as part of professional identity	Long-term institutionalization of Green Hospital principles
Integration with Policy	Leaders align practices with governance frameworks	Nurses follow structured KPIs and indicators	Hospital meets national and international sustainability standards

Table 4. Dimensions of Nurses' Green Behavior in Green Hospitals

Dimension	Description	Example Practice	Indicator / KPI	Reference Standard
Waste Management	Proper segregation and disposal of infectious vs. non-infectious waste	Nurses using color-coded bins for sharps and general waste	% Segregation compliance	WHO Safe Waste Practices (2023)
Energy Conservation	Reducing unnecessary use of electrical devices	Switching off idle monitors, lights, and equipment	kWh per bed-day ↓	WHO Low-Carbon Framework 2020
Water Conservation	Efficient clinical water use	Reporting leaks, using low-flow cleaning practices	Liters per bed-day ↓	WHO Facility Guidance (2020)
Materials & Chemicals	Preference for safer, eco-labeled, and DEHP-free products	Adopting DEHP-free IV sets and reusables	% Eco-labeled items used	GGHH Goal: Safer Chemicals 2020
Patient & Family Education	Informing patients about sustainability practices	Educating patients on waste sorting or energy saving at home	# Counseling sessions	WHO Workforce Engagement 2023
Leadership & Advocacy	Acting as green champions within units	Nurses leading sustainability committees	% Staff participation	GGHH Goal: Leadership 2020

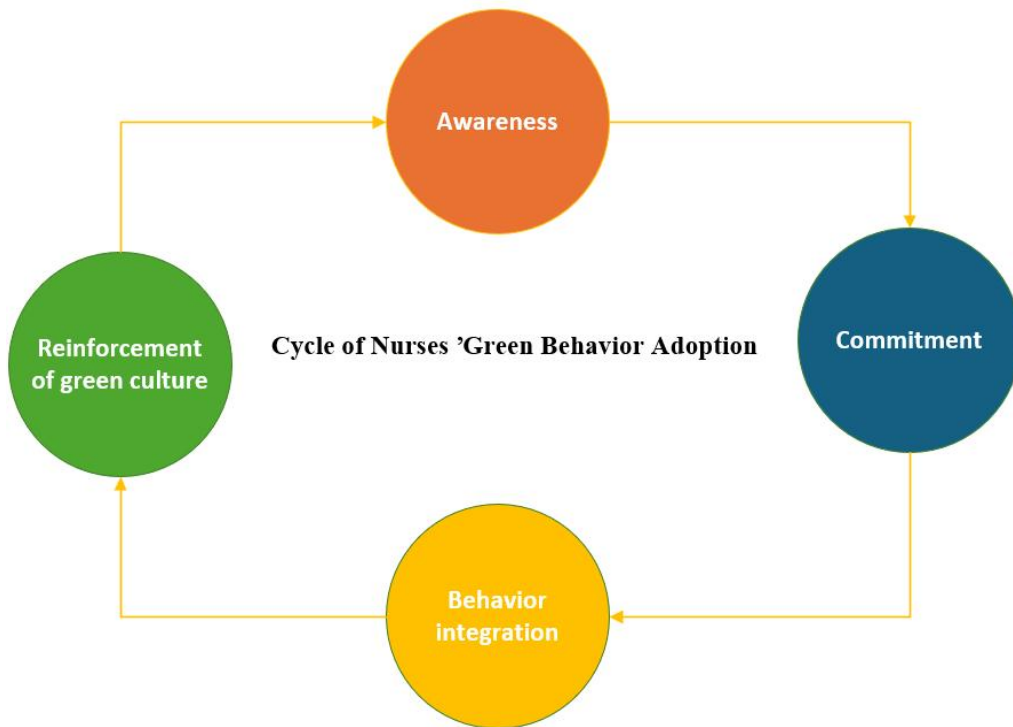
Figure 3. Cycle of Nurses' Green Behavior Adoption**Figure 4. Pathways of Nurses' Green Behavior in Clinical Practice**

Table 5. Integrated Framework: Nurses' Roles, Indicators, KPIs, and Standards for Green Hospitals

Domain	Primary Nursing Role	Indicator / KPI	Data Source	WHO / GGHH Standard
Waste	Segregate infectious vs. non-infectious waste	% Segregation compliance	Waste audits, facility logs	WHO Safe Waste Practices (2021); GGHH "Waste" Goal 2020
Energy	Conserve electricity at point-of-use	kWh per bed-day	Utility bills; energy meters	WHO Low-Carbon Framework; 2023 GGHH "Energy" Goal 2020
Water	Reduce unnecessary water use	Liters per bed-day	Meter readings; facility logs	WHO Facility Guidance; GGHH "Water" Goal
Materials & Chemicals	Adopt eco-labeled and DEHP-free supplies	% Eco-labeled/DEHP-free items used	Procurement records	GGHH "Chemicals" Goal
Procurement	Participate in sustainable purchasing decisions	% Green procurement rate	ERP analytics; purchase reports	WHO Green Procurement; GGHH "Purchasing" Goal
Education & Advocacy	Counsel patients/families on green practices	# Counseling sessions / month	EMR; education logs	WHO Workforce Engagement; GGHH "Leadership" Goal
Staff Engagement	Lead or join "green champion" initiatives	% Staff trained or involved	Training records; QI logs	WHO Workforce Training; GGHH cross-cutting

Table 6. Barriers and Enablers of Green Healthcare

Barrier	Enabler
Lack of funding or investment resources	Governmental or donor-based sustainability grants (e.g., WHO, Global Fund for Green Hospitals)
Staff/management resistance to change	Supportive and inspiring Green Transformational Leadership (GTL)
Limited awareness or knowledge of green practices	Continuous education, workshops, and competency-based sustainability training
Absence of clear policies or strategies	Strong national or institutional Green Governance frameworks
Limited availability of eco-friendly technologies	Sustainable procurement systems and partnerships with green suppliers
Workload pressures and lack of dedicated time	Integration of green practices into daily routines and performance metrics
Fragmented monitoring and reporting	Implementation of standardized KPIs and dashboards aligned with WHO/GGHH

Figure 5: WHO Framework – Pillars of Climate-Resilient and Environmentally Sustainable Health Care Facilities

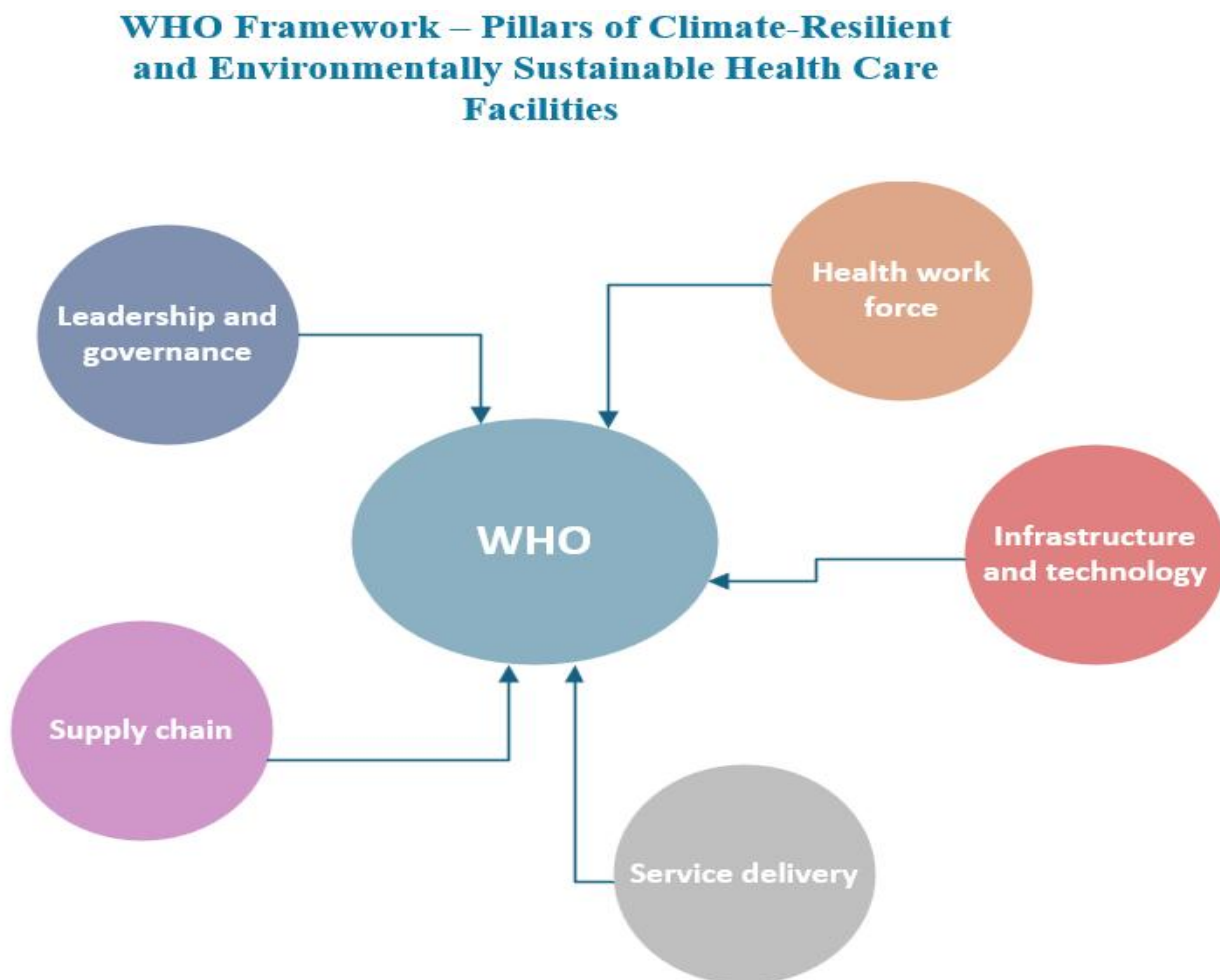


Figure 6. Integrated Model of Green Leadership, Nurses' Green Behavior, and Green Hospital Outcomes

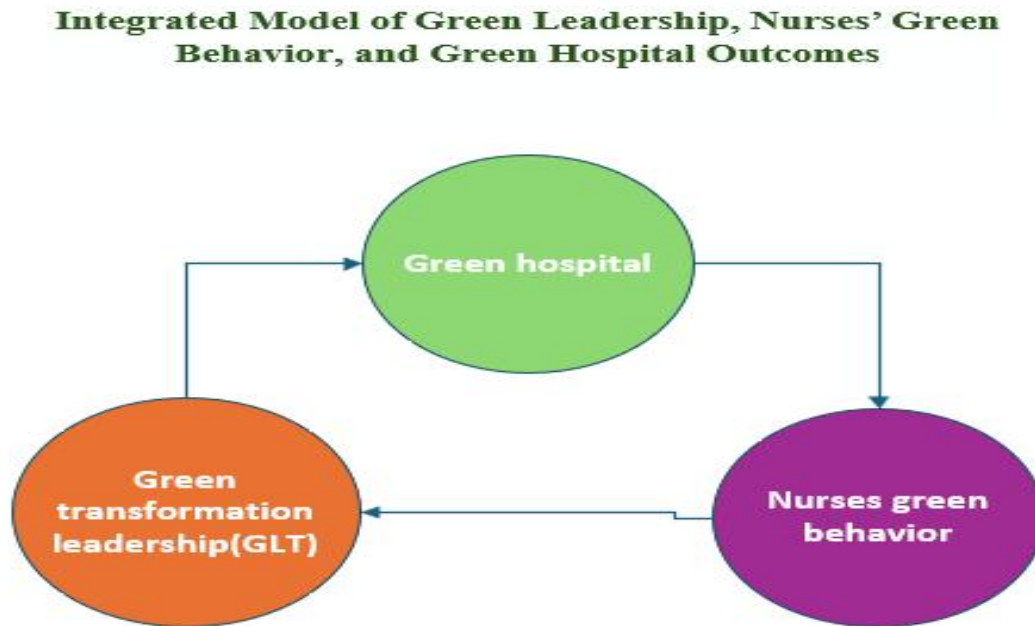


Table 7. Cost–Benefit Snapshot of Selected Green Hospital Initiatives

Initiative	Typical Costs (CapEx / OpEx)	Short-Term Benefits	Long-Term Benefits	Sources / Standards
Replace desflurane with lower-impact agents (e.g., sevoflurane; low-flow anesthesia)	Low–moderate (training, formulary updates)	Immediate GHG emissions drop; no hardware investment	Annual drug cost savings; reduced carbon footprint	WHO (2023); National anesthesia society reports
LED lighting + smart controls	Moderate CapEx	Electricity bill reduction within months	Persistent O&M savings; improved resilience	WHO (2023) Low-carbon health systems; GGHH Energy Goal
Solar PV for critical loads	Moderate–high CapEx	Offsets grid costs; improves reliability	Large lifetime savings; resilience to outages	WHO (2023) Operational Framework
Robust waste segregation	Low (training, bins, audits)	Reduced hazardous waste → lower disposal costs	Compliance with HCWM standards; safer workplace	WHO (2020) Blue Book; GGHH Waste Goal
Switch to DEHP-free IV sets	Possible procurement premium	Reduced chemical exposure risk	Regulatory compliance; reputational gain	SCHEER (2024) update on phthalates
Green procurement policies	Low–moderate (policy + ERP integration)	Visibility of footprint hotspots	Structural shift toward eco-labeled goods	GGHH Purchasing Goal; WHO governance pillars

Figure 7: Comparative Outcome: Traditional vs. Green- Aligned Hospital

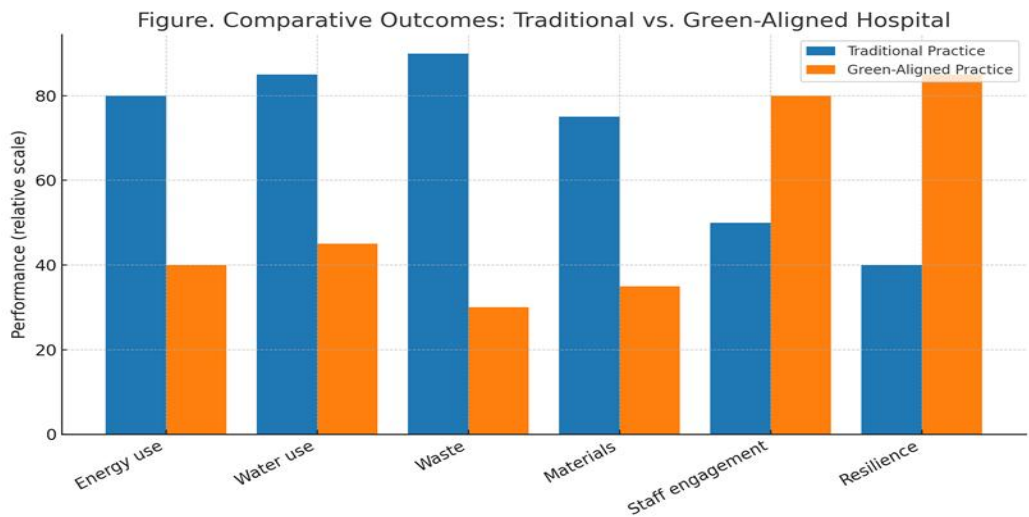


Figure 8. Pathway from GTL to Governance through Green Behavior and Green Hospital

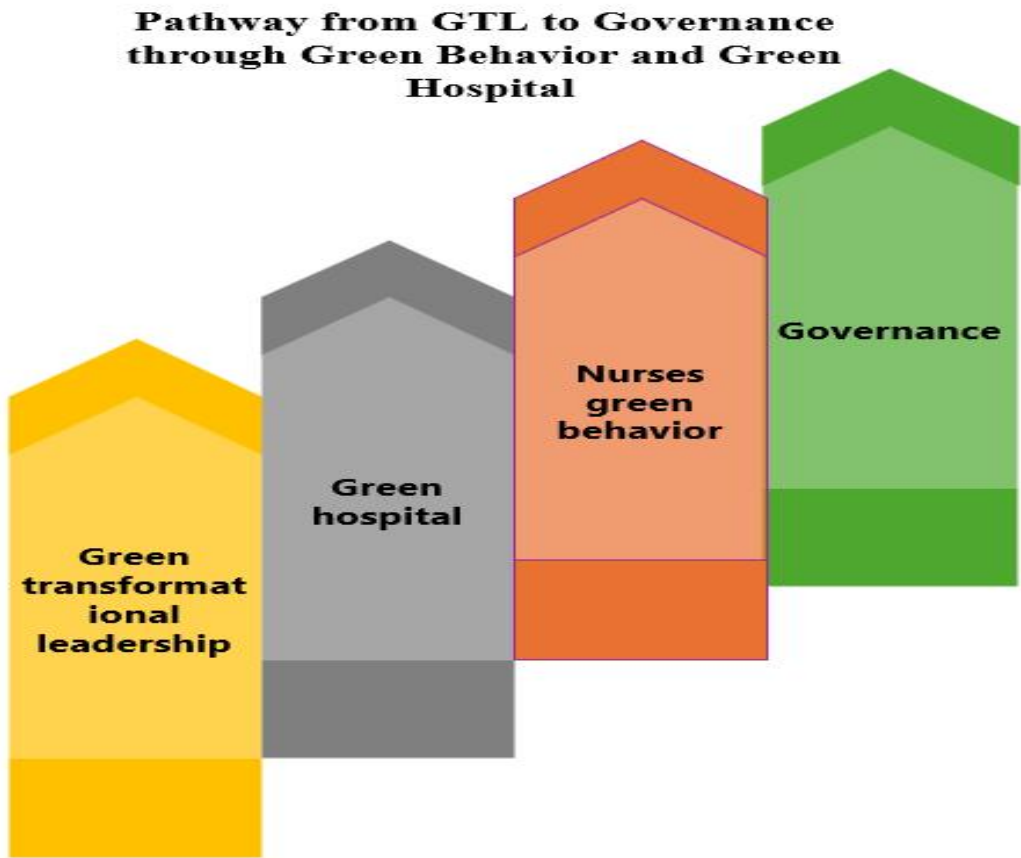


Table (1) presents a comparative overview of traditional leadership style versus Green Leadership style within healthcare settings. The analysis reveals that while traditional leadership emphasizes organizational goals, performance outcomes, efficiency, and productivity, Green Leadership reframes these dimensions by integrating sustainability and environmental responsibility into the leadership process (WHO, 2020). Specifically, Green Leadership promotes a sustainable and eco-friendly vision, drives motivation not only for performance but also for ecological responsibility, models environmentally conscious behavior, and embeds ecological and social impacts into decision-making.

Table (2) summarizes the comparative impact of different leadership styles on nurses' green behavior in healthcare. Autocratic leadership, while effective for rapid decision-making, fosters only minimal and short-term compliance with environmental practices. Democratic leadership enhances participation and morale, yet its sustainability outcomes remain inconsistent. Transactional leadership provides clear structures and measurable outputs but often ties green behaviors to extrinsic rewards, limiting long-term commitment. Transformational leadership, as outlined by Burns (1978) and Bass (1990), inspires motivation and innovation, achieving high engagement, though its ecological impact remains indirect without an explicit sustainability focus. In contrast, Green Transformational Leadership (GTL) emerges as the most aligned with sustainable healthcare goals, embedding eco-friendly practices into vision, motivation, and decision-making. GTL produces the strongest systemic adoption of green practices, embedding them into hospital culture (WHO, 2020;

Li et al., 2021; Al-Ghazali et al., 2022; Wang et al., 2025).

Figure (2) the model illustrates how Green Transformational Leadership (GTL) operates through four interconnected dimensions: idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration to embed sustainability into healthcare practice. Leaders who demonstrate role modeling (**idealized influence**) build credibility and encourage eco-friendly behaviors, while inspirational motivation highlights the power of a shared vision that aligns nurses' daily practices with institutional sustainability goals. Intellectual stimulation fosters innovation, enabling nurses to generate creative solutions for waste reduction and energy conservation, whereas individualized consideration demonstrates how mentoring and tailored support personalize sustainability and deepen behavioral change. Collectively, these dimensions illustrate a synergistic pathway that moves beyond traditional transformational leadership by explicitly embedding ecological consciousness into organizational culture, making GTL a decisive driver of sustainable healthcare (Bass, 1990; WHO, 2020; Li et al., 2021; Al-Ghazali et al., 2022; Wang et al., 2025).

Table (3) highlights the interplay between Green Transformational Leadership (GTL), nurses' green behavior, and Green Hospital outcomes. Leaders who demonstrate a sustainability vision and model eco-friendly practices encourage nurses to adopt similar behaviors, which translates into institutional policies and improved reputation. The table further emphasizes that motivating and supporting nurses shows tangible results, such as reduced resource consumption and stronger compliance with WHO and GHH standards. Encouraging innovation portrays nurses as active agents of change, while individualized mentorship underscores the long-term integration of sustainability into professional identity. Overall, the model demonstrates how GTL creates systemic pathways that

embed ecological consciousness into hospital culture and outcomes.

Table (4) demonstrates how nurses' green behavior in hospitals spans multiple dimensions, each directly tied to measurable outcomes and global standards. Effective waste management practices, such as segregation with color-coded bins, highlight the critical role of frontline compliance in reducing infection risks and meeting WHO waste guidelines. Similarly, energy conservation and water conservation behaviors show how everyday actions—like switching off idle devices or reporting leaks can significantly lower hospital resource footprints, with indicators tracked per bed-day (WHO, 2020).

The table also emphasizes the importance of safer material choices, where adopting DEHP-free and eco-labeled products illustrates alignment with GGHH goals on safer chemicals. In addition, patient and family education underscores the nurse's role as an educator, extending sustainability practices beyond the hospital walls. Finally, leadership and advocacy behaviors, such as leading unit-level sustainability committees, portray nurses as green champions whose participation directly shapes organizational culture (GGHH, 2020; WHO, 2023).

Figure (3) illustrates the cyclical process through which nurses adopt and sustain green behaviors in hospital settings. The cycle highlights how awareness and training generate initial behavioral change, which is then reinforced by role modeling, leadership support, and visible institutional outcomes. As compliance grows, positive feedback from measurable results (e.g., reduced waste, lower energy use) demonstrates the value of sustainability, motivating further adoption and normalization of practices. This

reinforcing loop underscores how sustainability becomes embedded in professional identity, ensuring that green behavior is not episodic but continuous and self-sustaining (WHO, 2020; Li et al., 2021).

Figure (4) shows the different pathways through which nurses translate sustainability principles into daily clinical practice. It emphasizes the diversity of actions—from waste segregation and safe chemical use to patient education and advocacy—that together shape the ecological footprint of hospitals. The pathways demonstrate how leadership influence, policy alignment, and individual responsibility interact to guide nurses toward consistent green practices. Moreover, the figure portrays how frontline decisions connect to broader hospital outcomes, linking micro-level behaviors with macro-level sustainability goals (GGHH, 2020; Al-Ghazali et al., 2022).

Table (5) demonstrates how nurses' roles in sustainability are systematically integrated with measurable indicators, KPIs, and global standards. The framework highlights the alignment between daily nursing practices such as waste segregation, energy and water conservation, or eco-labeled material use and institutional monitoring tools like audits, meters, and procurement records. It also emphasizes that nurses extend their impact beyond clinical tasks by contributing to sustainable procurement, patient education, and advocacy, thereby linking frontline behaviors with broader governance strategies. By embedding nursing contributions into standardized KPIs and data sources, the framework underscores how nurses operationalize WHO and GGHH sustainability goals, making them central agents of institutional transformation.

Table (6) illustrates the dynamic balance between barriers and enablers that shape the adoption of green healthcare practices. It shows that common challenges such as limited funding, staff resistance, knowledge gaps, and workload pressures can be effectively countered by targeted enablers, including donor-based grants, supportive leadership, competency-based training, and integration of green practices into daily routines. The table further demonstrates how systemic issues like absent policies or fragmented monitoring are mitigated through robust governance frameworks and standardized KPIs aligned with WHO and GGHH. Overall, the framework underscores that addressing barriers through enabling mechanisms is essential for achieving sustainable transformation at both institutional and national levels.

Figure (5) illustrates the WHO framework for climate-resilient and environmentally sustainable healthcare facilities, outlining the essential pillars that guide institutions toward ecological responsibility. The model highlights structural domains such as governance, infrastructure, workforce, and service delivery, all of which must adapt to both environmental challenges and patient safety requirements. By embedding resilience into core health system functions, the framework demonstrates how hospitals can simultaneously prepare for climate risks and reduce their ecological footprint. It also underscores the global applicability of these pillars, offering a strategic pathway for facilities to align local initiatives with international sustainability standards (WHO, 2020).

Figure (6) conceptualized the integrated model that connects Green Transformational Leadership (GTL), nurses' green behavior, and Green Hospital outcomes into one coherent

system. The figure emphasizes how leadership dimensions vision, motivation, innovation, and support directly influence nurses' daily eco-friendly practices, ranging from waste segregation to patient education. These behaviors, in turn, demonstrate measurable institutional outcomes such as reduced energy and water use, improved compliance with WHO/GGHH, and enhanced hospital reputation. The model further portrays the cyclical reinforcement between governance, workforce engagement, and sustainability results, underscoring GTL as a pivotal driver for embedding ecological consciousness into hospital culture and outcomes (Li et al., 2021; Al-Ghazali et al., 2022; Wang et al., 2025).

Table 7 indicates that how selected green hospital initiatives balance upfront costs with both short- and long-term sustainability benefits. Replacing high-impact anesthetic agents such as desflurane with alternatives like sevoflurane **demonstrates** immediate reductions in greenhouse gas emissions while also **showing** long-term drug cost savings and compliance with international guidelines. Similarly, investments in **LED lighting with smart controls** and **solar PV systems** portray how moderate to high capital expenditures generate persistent financial savings, improved resilience, and reduced dependency on non-renewable energy sources (WHO, 2023; GGHH). The table further **underscores** that relatively low-cost measures such as robust waste segregation and DEHP-free IV sets deliver disproportionate benefits, including safer workplaces, reduced chemical exposure, and enhanced reputational standing. Finally, the adoption of **green procurement policies** emphasizes the structural importance of integrating sustainability into purchasing systems,

enabling hospitals to track and reduce ecological footprints across the supply chain. Overall, Table (7) **demonstrates** that even modest investments in green initiatives create long-term financial, environmental, and regulatory gains, reinforcing the business case for sustainable healthcare.

Figure (7) compares clinical outcomes between hospitals operating under traditional models and those aligned with green principles, highlighting the tangible differences in efficiency, sustainability, and resilience. Traditional hospitals often demonstrate higher energy consumption, waste generation, and chemical dependence, while green-aligned hospitals show measurable improvements in efficiency, safety, and compliance with WHO and GGHH standards. This comparison underscores the systemic advantages of embedding eco-friendly practices into hospital culture, positioning green-aligned models as not only environmentally responsible but also cost-effective and resilient in the long term.

Figure (8) depicts the pathway linking Green Transformational Leadership (GTL) with governance outcomes through nurses' green behavior and hospital-level sustainability practices. The figure emphasizes how leadership vision, motivation, innovation, and support directly translate into nurses' daily eco-friendly actions, which then demonstrate measurable hospital outcomes such as reduced resource use and safer waste practices. These outcomes, when aligned with governance frameworks, portray how GTL not only shapes behavior but also anchors sustainability within institutional policy and accountability structures. Overall, the pathway highlights GTL as a critical driver connecting micro-level

practices to macro-level governance in healthcare sustainability.

Discussion

The findings summarized in **Table 1** provide a comparative interpretation of traditional leadership style versus Green Leadership style within healthcare organizations. The table shows that traditional leadership emphasizes efficiency, productivity, and performance-driven outcomes, while Green Leadership expands these priorities to include sustainability, environmental responsibility, and social accountability (**WHO, 2020**).

When compared with existing literature, these results are consistent with classical leadership theory, which highlights the limits of performance-centered models. **Burns (1978)** and **Bass (1990)** emphasized that transformational leadership transcends narrow organizational goals by motivating followers toward collective and higher-order purposes. Building on this, **Al-Ghazali et al. (2022)** and **Wang et al. (2025)** confirmed that Green Transformational Leadership (GTL) incorporates ecological values into the transformational framework, thereby aligning leadership with sustainability objectives.

Supportive evidence from **Li et al. (2021)** and **Othman et al. (2025)** demonstrates that nurses respond more positively to leaders who act as role models for eco-friendly practices, reinforcing the importance of “influence” and “vision” dimensions highlighted in Table 1. Similarly, **Moustafa et al. (2024)** found that leadership interventions embedding environmental values significantly enhanced nurses' creativity and participation in green initiatives, which

aligns with the “motivation” component of Green Leadership.

However, some contrasting perspectives exist. **Sobaih et al. (2022)** noted that in certain healthcare contexts, transformational styles did not automatically translate into environmental behaviors due to resource limitations and competing clinical priorities. **Torun (2023)** argued that the effect of leadership on green performance may be indirect and heavily mediated by organizational culture. These findings suggest that while Table 1 highlights the conceptual strengths of Green Leadership, its practical effectiveness may vary depending on contextual and structural factors.

In summary, **Table 1** illustrates not only a conceptual shift from traditional to Green Leadership but also reflects a debate in the literature regarding its translation into practice. Supportive studies highlight the potential of GTL to foster sustainable behaviors among nurses, whereas critical perspectives caution that leadership alone is insufficient without organizational resources and supportive policies. This underscores the need for integrated strategies combining leadership vision with institutional reinforcement to advance the Green Hospital model.

The findings presented in **Table 2** reinforce the literature that leadership style is a critical determinant of environmental performance in healthcare. Autocratic and transactional approaches, although effective in ensuring compliance, have limited influence on intrinsic motivation for sustainability. This is consistent with **Torun (2023)**, who noted that transactional leadership often restricts innovation and ties green behavior to short-lived rewards. Democratic leadership shows moderate effectiveness by fostering collaboration and engagement; however, its long-term impact on

sustainability is inconsistent due to time constraints and potential conflicts in decision-making (**WHO, 2020**). Transformational leadership, as emphasized by **Bass (1990)**, provides a foundation for innovation and commitment, but without embedding ecological values, its contribution to sustainable practices may remain indirect.

Green Transformational Leadership (GTL) distinguishes itself by explicitly aligning transformational leadership with ecological goals. Recent studies (**Li et al., 2021; Al-Ghazali et al., 2022; Wang et al., 2025**) confirm that GTL enhances nurses’ environmental awareness, strengthens organizational identity, and fosters green creativity, thereby bridging the gap between policy-level sustainability goals and bedside practice. Nevertheless, some authors caution that the success of GTL depends on supportive governance and organizational culture; without structural reinforcement, its long-term impact may be diluted (**Sobaih et al., 2022**).

In summary, **Table 2** demonstrates a continuum in the effectiveness of leadership styles, with GTL emerging as the most powerful driver of systemic green behavior among nurses. This underscores the need for healthcare organizations to integrate GTL into leadership development programs and institutional policies in order to achieve Green Hospital outcomes.

The figure 2 illustrates the four equally weighted dimensions of Green Transformational Leadership (GTL)—idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration—adapted from the classical transformational leadership model (**Burns, 1978; Bass, 1990**). Each dimension contributes 25%, emphasizing the balanced nature of GTL, where no single attribute alone is sufficient to foster sustainable

transformation in healthcare. Instead, effective leadership requires the integration of all four components to drive systemic change.

From a supportive perspective, idealized influence and inspirational motivation emerge as crucial in embedding environmental responsibility within organizational vision. Leaders who act as eco-role models and articulate a compelling sustainability vision significantly enhance nurses' environmental commitment (**Li et al., 2021; Wang et al., 2025**). Studies confirm that when nurses see leaders practicing waste segregation, advocating DEHP-free procurement, or championing renewable energy projects, they are more likely to internalize such behaviors (**Moustafa et al., 2024**).

Equally, intellectual stimulation is vital for encouraging innovative nursing-led solutions, such as energy-efficient clinical protocols or green supply chain initiatives. Recent evidence (**Moustafa et al., 2024**) shows that GTL fosters green creativity among nurses, enabling them to design and implement eco-friendly practices even under resource constraints. Individualized consideration, the final dimension, ensures that staff receive tailored support, training, and mentorship, reducing resistance to change and promoting long-term adoption of sustainability practices. However, critical voices argue that while GTL dimensions provide a strong theoretical foundation, practical effectiveness is uneven across healthcare settings. **Sobaih et al. (2022)** observed that individualized consideration may be difficult to operationalize in overstretched hospitals, where staff shortages limit leaders' capacity for one-to-one mentoring. Similarly, **Torun (2023)** notes that intellectual stimulation may not always lead to actual innovation unless hospitals provide resources and governance structures to implement new ideas. These critiques suggest that GTL, while conceptually robust, risks being aspirational without organizational alignment and structural enablers.

In summary, the figure demonstrates that GTL's four dimensions form a holistic leadership model that bridges environmental values with clinical practice. The literature strongly supports GTL as a predictor of

nurses' green behavior, but the effectiveness of each dimension depends on context, resources, and governance alignment. This reinforces **WHO's (2020, 2021)** call for integrating leadership development into broader institutional strategies for climate-resilient health systems. Thus, GTL should be understood not only as an individual leadership style but as a systemic catalyst, requiring organizational embedding to maximize its impact on Green Hospital outcomes.

The findings in **Table 3** illustrate the interconnected relationship between Green Transformational Leadership (GTL), nurses' green behavior, and the resulting Green Hospital outcomes. Specifically, the table highlights how leadership vision, motivation, innovation, and individualized support translate into measurable sustainability practices at the bedside, which in turn culminate in organizational-level outcomes such as policy integration, compliance with **WHO/GGHH** standards, and improved environmental performance.

When compared with existing literature, these results align closely with transformational leadership theory (**Burns, 1978; Bass, 1990**), which emphasizes leaders' ability to inspire and mobilize followers beyond self-interest. Studies such as **Li et al. (2021)** and **Wang et al. (2025)** confirm that GTL acts as a catalyst by embedding sustainability values into daily nursing practices—whether through waste segregation, the adoption of DEHP-free devices, or active participation in green initiatives. These findings echo **WHO's (2020)** framework, which underscores leadership and workforce engagement as core levers for achieving climate-resilient, sustainable health systems.

Supportive empirical evidence further demonstrates the role of nurses as mediators. For instance, **Moustafa et al. (2024)** documented that nurse leaders who explicitly mentor staff on sustainability foster higher rates of compliance and innovation in clinical units. Similarly, **Li et al. (2021)** showed that individualized support and intellectual stimulation significantly enhance nurses'

creativity in developing green solutions, thereby reinforcing the mechanisms outlined in Table 3.

However, some critical perspectives suggest caution. **Torun (2023)** noted that while leadership can spark green behaviors, systemic barriers such as limited resources, lack of policy enforcement, or competing clinical demands may hinder long-term institutionalization. This resonates with the “Integration with Policy” dimension in Table 3, highlighting that leadership alone cannot sustain transformation without governance frameworks and structural enablers.

In summary, **Table 3** advances the discussion by showing how micro-level leadership practices (GTL) cascade into meso-level staff behaviors and ultimately macro-level hospital outcomes. The evidence suggests that GTL is most effective when reinforced by policy integration and organizational alignment with global standards. Thus, Table 3 not only validates the mediating role of nurses’ behavior but also provides a roadmap for translating leadership vision into tangible hospital-wide sustainability outcomes.

Table 4 highlights the multi-dimensional nature of nurses’ green behavior within the Green Hospital framework. Each dimension waste management, energy conservation, water efficiency, safe material use, patient/family education, and leadership/advocacy captures how nurses operationalize sustainability in their daily clinical roles. The table also links these behaviors to measurable indicators (KPIs) and reference standards such as **WHO’s Safe Waste Practices (2023)** and the **GGHH Agenda**, ensuring accountability and benchmarking.

When situated within the broader literature, these findings align with **Wang et al. (2025)**, who argued that green behaviors among nurses act as the operational backbone of sustainable healthcare. By adhering to structured KPIs such as segregation compliance or energy intensity per bed-day, nurses translate global sustainability goals into tangible outcomes at the unit level. Similarly, **Li et al. (2021)** showed that nurses’

green behaviors mediate the effect of leadership on hospital-wide sustainability, reinforcing the role of staff as the “link” between vision and outcome.

The table also emphasizes the educational and advocacy role of nurses, consistent with **Moustafa et al. (2024)**, who demonstrated that staff-led patient education programs on waste and energy use extend the reach of Green Hospital initiatives into the community. This resonates with **WHO’s Workforce Engagement strategy (2023)**, which stresses that environmental sustainability must be integrated into both staff training and patient interactions.

However, challenges remain. Studies by **Torun (2023)** suggest that without adequate institutional support—such as sufficient time allocation, recognition mechanisms, or availability of eco-labeled products—nurses’ engagement in sustainability may decline due to workload pressures. This underscores the importance of coupling behavioral expectations with governance support, procurement strategies, and continuous training.

In summary, Table 4 demonstrates that nurses’ green behavior is not peripheral but central to achieving Green Hospital standards. By integrating these dimensions into monitoring frameworks and accreditation systems, hospitals can ensure that sustainability becomes embedded in nursing practice, thereby reinforcing the systemic outcomes illustrated in Table 3. This further validates the **WHO (2020, 2023)** position that workforce engagement is the linchpin for operationalizing sustainability in healthcare.

Figure 3 The cycle illustrated in this figure highlights the dynamic and iterative process through which nurses internalize and sustain green behaviors within healthcare organizations. The sequence—awareness, commitment, behavioral integration, and reinforcement of green culture—captures the transition from individual cognition to systemic cultural embedding.

Awareness represents the initial stage, where nurses are exposed to the importance of sustainability through

leadership communication, training programs, and institutional campaigns. As **Li et al. (2021) and Wang et al. (2025)** emphasize, awareness alone is insufficient; without reinforcement, it risks remaining superficial knowledge that does not alter practice.

Commitment follows as nurses begin to align personal and professional values with sustainability goals. This is often fostered by Green Transformational Leadership (GTL), which provides role modeling and inspirational motivation (**Al-Ghazali et al., 2022**). Studies by **Moustafa et al. (2024)** demonstrate that when leaders frame sustainability as a professional and ethical responsibility, nurses show stronger commitment to eco-friendly initiatives such as energy conservation and waste segregation.

Behavioral integration signifies the stage where green practices are consistently embedded into daily nursing workflows. Evidence from **Torun (2023)** indicates that this stage is particularly sensitive to organizational enablers, including workload management, provision of eco-labeled materials, and alignment with hospital policies. Without these supports, even committed nurses may face barriers to full integration.

Finally, reinforcement of green culture ensures that sustainability behaviors are not isolated or short-lived. At this stage, organizational systems such as audits, recognition programs, and feedback loops solidify green practices as the “new normal.” This resonates with **WHO’s (2020)** emphasis on culture as a determinant of climate-resilient healthcare systems. Reinforcement also “closes the loop” by re-generating awareness among new staff, creating a cyclical and self-sustaining model of transformation.

In summary, this cycle underscores the interdependence between leadership

influence, individual nurse behavior, and cultural reinforcement. While GTL catalyzes awareness and commitment, organizational structures are vital to sustain integration and cultural embedding. This cyclical view challenges linear models of change by emphasizing that sustainability in healthcare is not a one-time intervention but an evolving, iterative process that requires continuous nurturing. The cycle illustrated in **figure 4** which highlights the dynamic and iterative process through which nurses adopt and internalize green behaviors within clinical practice. It consists of four interlinked phases: awareness, commitment, behavioral integration, and reinforcement of green culture. Unlike linear models, this cyclical representation underscores that sustainability in healthcare is not a one-time intervention but an evolving process requiring continuous reinforcement and adaptation.

Awareness serves as the foundation, reflecting the extent to which nurses understand the environmental impact of healthcare practices. This aligns with findings from **Li et al. (2021)**, who emphasized that environmental awareness is a prerequisite for the development of pro-environmental intentions among healthcare staff. However, awareness alone is insufficient without subsequent commitment.

The commitment phase represents the transition from cognitive understanding to affective and behavioral intent. Nurses begin to recognize environmental stewardship as integral to their professional identity. **Wang et al. (2025)** observed that when nurses feel personally committed, they are more likely to sustain behaviors such as waste segregation and resource conservation.

Behavioral integration refers to the consistent application of green practices in daily workflows switching off idle equipment, adopting DEHP-free devices,

and incorporating patient education on eco-friendly practices. This step operationalizes leadership vision and policies at the bedside. Notably, **Moustafa et al. (2024)** showed that behavior is more likely to be integrated when leadership provides role models and reinforcement mechanisms.

Finally, reinforcement of green culture completes the cycle, feeding back into awareness and sustaining momentum. Hospitals that institutionalize sustainability through recognition systems, peer modeling, and policy embedding create cultures where green practices are normalized. The **WHO (2020)** framework similarly highlights culture and workforce engagement as critical for institutionalizing sustainability.

Critically, this cycle also demonstrates potential vulnerabilities. Research by **Torun (2023)** notes that without reinforcement, behavior adoption risks stagnation or reversal, particularly under high workload pressures. This suggests that while Green Transformational Leadership (GTL) is pivotal in initiating the cycle, governance structures and cultural reinforcement are equally essential to sustain it.

In summary, the cycle reflects a multi-level process in which leadership, individual commitment, and organizational culture interact to embed sustainability in nursing practice. It provides a practical roadmap for moving from awareness to institutionalization, reinforcing the central role of nurses as agents of green transformation within hospitals.

The findings summarized in **Table 5** provide a structured framework that connects nurses' roles with measurable indicators, key performance indicators (KPIs), and internationally recognized standards (**WHO, GGHH**). This integration is essential for

transforming sustainability from an abstract organizational goal into operational and measurable practices at the bedside.

At the waste domain, nurses act as frontline agents of environmental stewardship through accurate segregation of infectious and non-infectious waste.

WHO (2020) and GGHH (2020) stress that poor waste segregation is a critical source of environmental and health risks. By linking nursing behavior directly to measurable KPIs such as segregation compliance rates this framework ensures accountability and standardization, enabling hospitals to benchmark progress against global standards.

For energy and water conservation, the framework highlights how everyday nursing practices, such as switching off idle equipment or adopting low-flow clinical practices, can significantly reduce a hospital's environmental footprint. Evidence from **Wang et al. (2025)** demonstrates that hospitals with strong staff engagement in resource conservation achieve measurable reductions in kWh/bed-day and liters/bed-day, thereby validating the practicality of these indicators. Importantly, these actions are low-cost and scalable, making them applicable across both high- and low-resource hospitals.

In terms of materials and procurement, the framework emphasizes the critical role of nurses in advocating for eco-labeled and DEHP-free products. Procurement is often viewed as a managerial or administrative responsibility; however, GGHH's "Purchasing" goal and WHO's safer chemicals agenda underscore that nurse-led advocacy in procurement committees enhances the uptake of safer alternatives. This aligns with findings from **Hamza et al. (2025)**, which show that clinical staff involvement in procurement decisions accelerates the adoption of safer materials without compromising patient safety.

The education and advocacy domain extends sustainability beyond the hospital to patients, families, and the community. By counseling patients about eco-friendly practices, nurses act as multipliers of environmental awareness, creating ripple effects that extend far beyond institutional boundaries. **Li et al. (2021)** found that patient-centered education is a powerful enabler of green behavior, reinforcing the pivotal role of nurses as educators as well as caregivers.

Finally, the inclusion of staff engagement through green champions and training programs ensures cultural reinforcement and long-term institutionalization. **WHO (2020)** identifies workforce training as a cornerstone of climate-resilient health systems, while **GGHH** emphasizes leadership and staff involvement as cross-cutting enablers of success. Embedding staff engagement as a KPI not only measures participation but also ensures that sustainability becomes ingrained in professional identity and hospital culture. In synthesis, Table 5 demonstrates how nurses' daily practices can be operationalized into measurable outcomes, firmly aligned with **WHO and GGHH** standards. This framework highlights the synergy between leadership, behavior, and policy, ensuring that sustainability is not an isolated initiative but a systemic transformation process. By aligning individual nursing roles with institutional KPIs and global benchmarks, hospitals can achieve measurable progress toward Green Hospital goals while reinforcing the central role of nurses in advancing healthcare sustainability.

The analysis in **Table 6** provides a balanced perspective on the factors that either hinder or facilitate the transition toward sustainable healthcare systems. Barriers such as lack of funding, resistance to change, and absence of clear policies reflect long-standing structural

and cultural challenges in healthcare organizations. These findings resonate with **WHO (2020, 2023)** frameworks, which consistently highlight financing gaps, weak governance, and limited workforce awareness as major obstacles to scaling sustainable health interventions.

From the leadership dimension, staff and management resistance to change is one of the most significant barriers. Traditional hierarchical cultures in hospitals may slow adoption of innovative practices. However, the enabler role of Green Transformational Leadership (GTL) is evident: by inspiring a shared vision and role-modeling eco-friendly practices, GTL reduces resistance and builds staff motivation to embrace sustainability (**Li et al., 2021; Al-Ghazali et al., 2022**). This leadership-mediated cultural shift is essential for embedding sustainability into everyday clinical routines.

Knowledge and awareness deficits further weaken sustainability efforts, as frontline staff may lack exposure to environmental training. The enabler here is continuous education and training programs, aligned with WHO's capacity-building recommendations and the GGHH agenda. Evidence shows that when nurses receive structured training on waste segregation, safer chemical handling, and energy conservation, compliance rates and sustainability performance improve significantly (**Moustafa et al., 2024**).

At the system level, the absence of clear policies or strategies remains a critical barrier. Without national mandates or institutional frameworks, green practices risk remaining fragmented or voluntary. Conversely, strong governance structures and policy integration act as powerful enablers, ensuring accountability, standardization, and alignment with international frameworks such as **WHO's Operational Framework for Climate-Resilient Health Systems (2023)**.

Finally, operational barriers such as workload pressures and lack of dedicated time highlight the challenge of integrating sustainability into already strained clinical environments. Here, the enabler is mainstreaming green practices into daily nursing routines—for example, embedding waste segregation and resource

conservation into standard operating procedures and performance evaluations. This approach minimizes additional workload while reinforcing sustainability as part of professional identity.

In summary, Table 6 underscores the dual reality of green healthcare: while systemic and cultural barriers remain significant, effective leadership, governance, and workforce training can transform these challenges into opportunities. This analysis reinforces the broader literature that sustainable transformation in healthcare cannot rely solely on technological solutions; it requires integrated strategies that combine leadership, education, and governance to address both human and structural dimensions.

The findings illustrated in **Figure 5** align with WHO's global framework, which emphasizes that building environmentally sustainable and climate-resilient hospitals requires a multi-pillar approach (**WHO, 2020; WHO, 2023**). Unlike models that rely solely on leadership or workforce behavior, this framework integrates five interdependent domains: leadership and governance, health workforce, infrastructure and technology, supply chain, and service delivery, each of which is necessary but not sufficient on its own.

When compared with existing literature, the model is consistent with studies showing that sustainability in healthcare is not achieved through isolated initiatives. For example, **Li et al. (2021)** demonstrated that nurses' green behavior significantly improves waste segregation and energy conservation, but long-term impact requires institutional governance and infrastructure investment. Similarly, **Moustafa et al. (2024); Wang et al. (2025)** stressed that green leadership must be reinforced by organizational systems to avoid fragmented or temporary results.

Each pillar reinforces the others:

- Leadership & Governance anchors sustainability within hospital strategy and aligns it with national

health policies. Without this, even strong leadership at the unit level may remain limited (**Torun, 2023**).

- Health Workforce operationalizes policies through daily clinical practices, supporting the evidence that nurses are central to bridging leadership vision with bedside sustainability.
- Infrastructure & Technology provides the enabling environment (e.g., renewable energy, green buildings), echoing **WHO's (2023)** call for hospitals to combine behavioral change with systemic redesign.
- Supply Chain highlights that sustainable procurement (e.g., DEHP-free devices) is critical to prevent environmentally harmful practices, confirming **SCHEER (2024)** findings.
- Service Delivery closes the loop by embedding environmental principles directly into patient care, linking ecological outcomes with patient safety and satisfaction.

In summary, **Figure 5** demonstrates that achieving Green Hospital outcomes is a systemic process requiring alignment across policy, workforce, infrastructure, and clinical service. While previous tables emphasized the role of Green Transformational Leadership (GTL) and nurses' green behavior, this figure situates those micro-level drivers within a macro-level institutional roadmap. The integration of these pillars reflects WHO's argument that sustainability in healthcare must be embedded in both organizational culture and governance structures, ensuring resilience, accountability, and measurable impact.

The integrated model presented in **Figure 6** captures the dynamic relationship between Green Transformational

Leadership (GTL), nurses' green behavior, and the realization of Green Hospital outcomes. It illustrates how leadership acts as the initiating force, nurses' actions function as the mediating mechanism, and the Green Hospital represents the systemic outcome.

This aligns with prior leadership theory, where **Burns (1978) and Bass (1990)** emphasized that transformational leadership extends beyond organizational performance to inspire followers toward higher collective purposes. By embedding environmental values, GTL operationalizes this vision into sustainable healthcare practice (**Al-Ghazali et al., 2022**).

The figure highlights GTL as the starting point, consistent with **Li et al. (2021) and Wang et al. (2025)**, who demonstrated that leaders who model eco-friendly behaviors and articulate a compelling sustainability vision significantly improve staff engagement. Nurse leaders, in particular, serve as role models who bridge institutional sustainability goals with daily bedside practices, reinforcing the vision, motivation, and support dimensions of leadership.

The second layer of the model underscores the critical mediating role of nurses. Representing a large number of the healthcare workforce (**Li et al., 2021**), their daily practices waste segregation, energy and water conservation, adoption of safer materials, and patient education translate leadership inspiration into measurable outcomes. This finding resonates with **Moustafa et al. (2024)**, who showed that nurses' consistent engagement in sustainability practices leads to long-term institutional transformation.

The final layer shows how nurses' behavior aggregates into systemic hospital outcomes. These include reduced carbon

emissions, safer environments, compliance with **WHO and GGHH** sustainability standards, and improved patient/community trust. **WHO (2020, 2023)** emphasizes that climate-resilient hospitals can only emerge when micro-level actions are scaled into organizational culture and governance.

While the model underscores a clear causal pathway, some studies caution against over-reliance on leadership alone. **Sobaih et al. (2022) and Torun (2023)** argue that without governance structures and resource allocation, GTL's impact may be diluted. This suggests that although Figure 6 captures the direct pathway from leadership to outcomes, the model must be understood within broader systemic contexts.

In summary, Figure 6 highlights the chain of influence: GTL inspires, nurses operationalize, and hospitals transform. This conceptualization advances the literature by demonstrating how leadership vision is not just an abstract ideal but a concrete driver of environmental and clinical outcomes. It also underscores the importance of positioning nurses at the center of sustainability transitions, thereby ensuring that Green Hospitals are both achievable and resilient.

The findings presented in **Table 7** highlight the economic and environmental trade-offs of adopting key green hospital initiatives. A critical observation is that many interventions, while requiring initial investment (CapEx), generate both short-term operational benefits and long-term sustainability gains, aligning with **GGHH (2020) WHO (2020, 2023)**.

Recommendations for climate-resilient health systems.

At the pharmaceutical level, replacing desflurane with lower-impact anesthetic agents (such as sevoflurane or adopting low-flow anesthesia) demonstrates immediate reductions in greenhouse gas emissions, with

minimal cost implications beyond training and formulary adjustments. National anesthesia societies and **WHO (2023)** emphasize that this intervention offers one of the fastest and most cost-effective pathways to decarbonizing perioperative care.

In terms of infrastructure and energy use, LED lighting combined with smart controls exemplifies a moderate-cost intervention that yields rapid electricity savings, improved resilience, and lower maintenance needs. Evidence from **WHO's Low-Carbon Health Systems framework (2023)** confirms that energy efficiency measures like LEDs deliver significant returns on investment within months. At a larger scale, solar PV installations for critical loads require higher upfront costs but secure resilience against grid instability while providing substantial lifetime cost savings and emissions reductions particularly important in regions vulnerable to power outages.

The waste domain highlights that robust segregation programs represent a low-cost but high-impact intervention. As **WHO's Blue Book (2020)** underlines, proper waste segregation reduces hazardous waste volumes, lowers disposal costs, and improves occupational safety for healthcare workers. These findings reinforce the point that behavioral interventions, when institutionalized, can deliver significant sustainability benefits at minimal cost.

Shifting to materials and procurement, adopting DEHP-free IV sets and establishing green procurement policies may involve a procurement premium or modest policy integration costs. However, the long-term benefits ranging from reduced chemical exposure risks to enhanced compliance with international regulatory frameworks (**SCHEER, 2024**) position these actions as strategic investments in both patient and staff safety. Furthermore, **GGHH's Purchasing Goal (2020)** emphasizes procurement as a systemic driver of sustainability, enabling structural transformation of hospital supply chains.

Collectively, Table 7 demonstrates that hospitals can strategically prioritize initiatives by balancing cost, feasibility, and

environmental impact. Behavioral changes (e.g., anesthetic substitution, waste segregation) offer rapid wins, while infrastructural and procurement reforms secure long-term resilience and alignment with international sustainability frameworks. This analysis reinforces **WHO's (2020, 2023)** argument that green healthcare investments are not only environmentally responsible but also economically prudent, with many initiatives generating measurable savings that can be reinvested in further sustainability efforts.

The findings illustrated in **Figure 7** present a clear contrast between traditional hospital models and green-aligned hospitals, emphasizing the systemic transformation required to integrate sustainability into healthcare operations. Traditional practices often prioritize immediate efficiency and clinical performance, but they also carry significant hidden costs in terms of environmental degradation, hazardous waste generation, and weak resilience to climate-related disruptions (**WHO, 2020; GGHH, 2020**). By contrast, green-aligned hospitals seek to balance clinical outcomes with ecological responsibility, promoting reduced carbon emissions, safer materials, improved resource efficiency, and stronger workforce engagement.

Advocates of green-aligned hospitals highlight that such models deliver both clinical and environmental dividends. **WHO (2023)** and the Global Green and Healthy Hospitals (GGHH) network stress that reducing energy and water intensity, replacing toxic materials, and embedding green procurement practices create safer therapeutic environments for patients and staff. Studies by **Li et al. (2021)** and **Wang et al. (2025)** show that aligning leadership with sustainability priorities fosters greater nurse engagement, which in turn leads to measurable gains in waste reduction, resilience, and patient

satisfaction. Furthermore, evidence suggests that green hospitals demonstrate better long-term cost efficiency through reduced utility expenses and minimized hazardous waste disposal costs.

However, some scholars caution that the transition from traditional to green-aligned systems is neither linear nor universally successful. **Torun (2023)** argues that resource constraints, competing patient safety demands, and inadequate policy enforcement may hinder the realization of sustainability goals. **Sobaih et al. (2022)** similarly warn that without robust governance and funding, green initiatives risk becoming fragmented or symbolic rather than transformational. In low- and middle-income contexts, the adoption of advanced infrastructure (such as renewable energy systems) may face significant financial and technical barriers, limiting the scalability of green-aligned models.

In light of these perspectives, Figure 7 underscores the importance of situating green-aligned hospitals not merely as aspirational ideals but as operational imperatives within the global health agenda. The evidence indicates that while green models offer substantial advantages in resilience, safety, and sustainability, their success is contingent upon leadership commitment particularly through Green Transformational Leadership (GTL) and institutional reinforcement via governance frameworks. From the researcher's perspective, the comparative outcomes highlight a pathway forward: leveraging nurse-led green behaviors and leadership-driven initiatives to gradually embed sustainable practices into hospital systems, thereby creating resilient, patient-centered institutions capable of meeting both clinical and environmental demands.

Figure 8 presents a sequential pathway where Green Transformational Leadership

(GTL) acts as the initiating force, nurses' green behavior operates as the mediating mechanism, and Green Hospital outcomes emerge as the systemic result eventually linking forward to governance structures that institutionalize sustainability. This pathway captures the dynamic interplay between leadership, behavior, and organizational transformation, highlighting the need to move beyond individual initiatives toward long-term policy alignment.

Research strongly supports this causal chain. **Li et al. (2021)** and **Wang et al. (2025)** confirm that GTL significantly predicts nurses' adoption of pro-environmental practices, such as safe waste segregation, energy conservation, and use of DEHP-free medical products. These micro-level behaviors accumulate into meso-level hospital outcomes reduced carbon footprint, cost savings, and improved patient/staff safety that align with **WHO's (2020, 2023)** framework for climate-resilient, environmentally sustainable healthcare. Furthermore, the **GGHH network (2020)** emphasizes that nurse-led sustainability practices, once scaled, directly contribute to achieving hospital-wide performance targets across waste, water, energy, and procurement domains.

At the same time, some scholars argue that the pathway illustrated in Figure 8 risks oversimplification. **Sobaih et al. (2022)** caution that leadership alone cannot guarantee sustained transformation if hospitals lack governance structures that mandate accountability. Similarly, **Torun (2023)** points out that while green behaviors at the nursing level can drive local improvements, they may remain fragmented and short-lived in the absence of formal governance mechanisms and financial investment. In resource-constrained settings, even strong

leadership may fail to translate into systemic change if procurement policies, infrastructure, and national regulations do not support sustainability goals.

Researcher's Interpretation. Taken together, Figure 8 emphasizes that GTL is the catalyst, nurses' green behavior is the bridge, and governance is the anchor. Leadership inspires and models sustainability, nurses translate vision into daily practice, and governance ensures that these practices are institutionalized, measurable, and resilient over time. From the researcher's perspective, this pathway offers a practical roadmap: hospitals should invest in developing GTL competencies among nurse leaders, support frontline staff in operationalizing sustainable practices, and ultimately embed these practices into governance frameworks to ensure continuity. By framing GTL not as an isolated driver but as the starting point in a governance-oriented continuum, this model positions leadership-driven nursing behaviors as essential precursors to sustainable, system-wide transformation in healthcare.

Implications

Policy: Health authorities and accreditation bodies should embed GTL-aligned sustainability indicators into quality and patient safety standards, link reporting to WHO/GGHH-aligned KPIs, and incentivize compliance through funding and procurement criteria (e.g., safer materials, DEHP-free devices). Positioning Governance as the capstone ensures continuity, accountability, and cross-hospital comparability.

Practice (Hospital & Nursing Management): Hospitals should develop GTL-capable leadership pipelines (training, mentoring), designate unit-based green nursing champions, and deploy real-time dashboards tracking energy/water

intensity, waste segregation compliance, and adoption of eco-labeled products. Embedding these metrics in performance reviews and unit QI cycles converts green behavior from ad hoc initiatives into routine clinical practice.

Methodological/Measurement: The indicators and KPIs proposed here support standardized monitoring and facilitate benchmarking. Hospitals can adopt monthly audits (e.g., segregation compliance $\geq 90\%$), quarterly procurement analytics (eco-labeled/DEHP-free adoption), and trend analyses of kWh and liters per bed-day—anchored to WHO/GGHH definitions to ensure validity and transferability.

Future Research: Rigorous empirical testing of the proposed pathway is needed. Priorities include:

- **Multilevel/mediation models** (e.g., SEM) to quantify GTL → Green Behavior → Green Hospital effects.
- **Longitudinal and quasi-experimental designs** evaluating GTL interventions (leadership training/mentoring) on unit-level KPIs and patient/occupational safety outcomes.
- **Cross-context comparisons** (high- vs. low-resource settings) to assess generalizability and cost-effectiveness.
- **Governance-focused studies** that analyze how board policies, accreditation alignment, and green procurement **institutionalize** leadership- and behavior-driven gains over time.

Conclusion

This study synthesizes global and regional evidence to examine the interplay between **Green Transformational Leadership (GTL), nurses' green behavior**, and the

development of Green Hospitals. By integrating leadership theories with the **World Health Organization's (WHO, 2020; 2021)** frameworks for climate-resilient and environmentally sustainable health systems, the study provides a comprehensive pathway for embedding sustainability into clinical and organizational practice.

1. The influence of Green Transformational Leadership (GTL) on nurses' green behavior

Evidence from recent literature demonstrates that GTL serves as a **primary driver** of green transformation in healthcare. Leaders who inspire, model, and reinforce eco-friendly values cultivate higher levels of environmental awareness, responsibility, and commitment among nurses (Li et al., 2021; Wang et al., 2025). By promoting shared environmental goals and role modeling sustainable conduct, transformational leaders translate their vision into measurable behavioral change, aligning daily clinical practices with hospital sustainability objectives.

2. The mediating role of environmental awareness, commitment, creativity, and identity

The review highlights that **mediating psychological and organizational factors**—such as environmental awareness, commitment, green creativity, and green organizational identity—explain how GTL impacts nurses' behavior. Awareness builds understanding, commitment ensures long-term adherence, creativity drives innovation in waste reduction and resource use, and organizational identity sustains collective responsibility. Together, these mediators strengthen the link between leadership influence and sustainable nursing practices across units and departments.

3. Effective leadership behaviors and strategies within the GTL framework

Specific leadership behaviors within the GTL model—**inspirational motivation, intellectual stimulation, individualized consideration, and idealized influence**—emerge as the most effective strategies for promoting sustainability. Through open communication, recognition, and empowerment, leaders encourage nurses to develop innovative, eco-conscious solutions. Practical approaches include environmental education, team-based sustainability projects, and the integration of green performance indicators within appraisal systems. These evidence-based strategies foster a proactive and creative nursing workforce dedicated to environmental stewardship.

4. Integration of GTL and nurses' behavior in developing Green Hospitals

The convergence of transformational leadership and nurses' green behavior provides the **foundation for Green Hospital transformation**. Nurses operationalize sustainability goals through waste segregation, rational resource use, and patient education, thereby translating leadership vision into measurable ecological outcomes (Moustafa et al., 2024). The review also confirms that hospitals can start with **low-cost, high-impact initiatives**—such as reducing single-use plastics, conserving energy and water, and introducing recycling systems—before scaling up to systemic reforms like renewable energy and green building design (WHO, 2020; Torun, 2023). Phased implementation and procurement reforms are key enablers of this transition.

5. Contextual and organizational factors influencing GTL impact

Contextual enablers such as **governance structures, accreditation systems, and organizational culture** play a vital moderating role. Embedding sustainability indicators into accreditation and quality

frameworks ensures that environmental goals are directly linked to patient safety and hospital performance (WHO, 2020). Conversely, limited resources, lack of incentives, and bureaucratic barriers can weaken leadership influence. Therefore, integrating sustainability within governance and accountability systems is essential for maintaining long-term progress and fostering institutional resilience.

6. Toward an integrated framework for sustainable healthcare

The synthesis establishes that sustainability in healthcare requires **multi-level integration**: GTL as the catalyst, nurses' green behavior as the mediating mechanism, and Green Hospital policies as the institutional outcome (Sobaih et al., 2022). This framework promotes resilience by reducing environmental impact, enhancing occupational safety, and improving patient care. Supported by WHO guidelines and global best practices, the proposed model offers a **universal roadmap** adaptable to diverse contexts—from high-resource hospitals implementing advanced infrastructure to low-resource settings relying on nurse-led environmental initiatives. Ultimately, it positions healthcare organizations as key contributors to global sustainability and planetary health.

Recommendations

1. Policy and Regulatory Level

- Integrate GTL and Green Hospital indicators into national and regional accreditation systems, aligning sustainability metrics with patient safety and quality improvement standards (WHO, 2020).
- Mandate sustainability-focused procurement policies, such as the elimination of DEHP-containing devices and prioritization of eco-

labeled medical products, backed by supplier certification and compliance monitoring (SCHEER, 2024).

- Introduce financial incentives (e.g., tax credits, green funds, sustainability grants) for hospitals that achieve measurable green milestones, such as reductions in hazardous waste or carbon intensity.
- Develop national climate-resilient hospital strategies, embedding sustainability into healthcare disaster preparedness and resilience planning.

2. Hospital Governance and Management

- Establish a Sustainability Governance Committee or appoint a Chief Sustainability Officer responsible for coordinating green initiatives across clinical and administrative departments.
- Implement a modular Green Hospital transition plan, starting with high-impact, low-cost measures (LED retrofits, waste segregation) before scaling toward capital-intensive interventions (renewable energy, green building standards).
- Embed sustainability into hospital KPIs and annual performance reviews, ensuring that environmental responsibility is recognized as a key dimension of hospital excellence.
- Foster inter-hospital benchmarking through participation in global networks such as the Green Global Healthy Hospitals (GGHH) to share best practices and monitor progress.

3. Nursing and Clinical Leadership

- Train and designate Green Nursing Champions in every clinical unit to lead green practices, mentor peers, and ensure compliance with waste reduction, sustainable procurement, and energy-saving initiatives (Li et al., 2021).
- Integrate environmental sustainability modules into nursing education, professional development, and competency frameworks, making green practices a core aspect of clinical excellence.
- Encourage nurse-led innovation in sustainable care practices, empowering nurses to design and pilot eco-friendly interventions (e.g., paperless documentation, safe reusables, patient education programs).
- Establish nursing metrics for green behavior (e.g., waste segregation compliance, patient education on environmental responsibility) as part of clinical audits.

4. Research and Technical Implementation

- Promote applied research projects in hospitals and nursing schools that evaluate the effectiveness of green practices (e.g., PVC/DEHP-free substitution, waste reduction strategies, renewable energy integration) on both patient outcomes and environmental performance.
- Establish collaborative research partnerships between healthcare institutions, universities, and international agencies (e.g., WHO, GGHH) to generate context-specific evidence on green hospital interventions.
- Encourage nurse-led research initiatives that measure the impact

of Green Transformational Leadership (GTL) on green behavior adoption and link outcomes directly to hospital sustainability performance indicators.

- As a continuation of this research, it is recommended to investigate the role of **Green Governance** in institutionalizing sustainability healthcare.

List of Abbreviations

Abbreviation	Full Form
CBAHI	Central Board for Accreditation o
CapEx	Capital Expenditure
DEHP	Di(2-ethylhexyl) phthalate
EMR	Electronic Medical Record
ERP	Enterprise Resource Planning
GGHH	Global Green and Healthy Hospit
GHG	Greenhouse Gas
GTL	Green Transformational Leadersh
HCWM	Healthcare Waste Management
IV	Intravenous
JCI	Joint Commission International
KPI	Key Performance Indicator
LMS	Learning Management System
O&M	Operation and Maintenance
OpEx	Operational Expenditure
PVC	Polyvinyl Chloride
QI	Quality Improvement
SCHEER	Scientific Committee on Health, Risks
UGHF	Universal Green Hospital Framew
WHO	World Health Organization

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