

ENVIRONMENTAL SUSTAINABILITY IN HOSPITAL CONTEXTS

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ABSTRACT

Environmental sustainability is a global challenge, and the hospital sector, despite its mission to preserve health, generates significant environmental impacts that are often underestimated. Hospitals consume a lot of energy, produce waste, and use chemicals, which can contribute to environmental degradation if not properly managed. Hospital environmental management must evolve toward a comprehensive vision that encompasses sustainability as an ethical, social, and ecological responsibility.

The Global Agenda for Green and Healthy Hospitals (2011) proposes a framework with ten goals to guide hospitals toward a more sustainable and efficient healthcare system. These goals include leadership, chemical management, waste reduction, energy efficiency, responsible water use, improved transportation, sustainable food supply, safe pharmaceutical management, green building construction, and sustainable procurement.

A study of ten hospitals in Tucumán revealed uneven progress in implementing these goals. While there has been progress in waste management and energy efficiency, areas such as sustainable transportation, food management, and green infrastructure show limited development. Adopting green hospital practices is crucial to reducing the sector's ecological footprint and strengthening the link between human health and the environment.

KEY WORDS: Hospitals; Health; Sustainability; Environmental Management

INTRODUCTION

In the current global context—where climate change and biodiversity loss are recognized as the most pressing challenges of our time (UNESCO, 2021)—environmental sustainability has become a cross-cutting priority across multiple sectors, including healthcare. According to the Global Risks Report (2023), the three most critical risks identified worldwide are the failure to mitigate and adapt to climate change, along with natural disasters and extreme weather events. Addressing these issues requires an urgent, coordinated response from governments, organizations, and citizens.



Although hospitals are primarily dedicated to preserving and restoring human health, they also generate significant environmental impacts that are often underestimated or inadequately managed. Recent studies highlight that hospitals share many characteristics with industrial sectors in terms of energy use, waste generation, and chemical consumption. Without appropriate sustainability measures, healthcare facilities can become sources of environmental degradation (León Avendaño, 2019).

In this regard, hospital environmental management must shift from a focus solely on disease prevention to an integrated vision that considers sustainability as an ethical, social, and ecological responsibility. Historically, the health sector has been one of the least engaged with environmental issues, despite the fact that environmental factors contribute to more than 23% of global mortality (WHO, 2016).

Faced with these challenges, sustainability must be understood as a strategic institutional management model that aims to meet present needs without compromising the ability of future generations to meet theirs (Brundtland, 1987). This involves adopting tools and indicators capable of assessing environmental sustainability in hospitals while integrating social, economic, and ecological criteria into decision-making.

Fortunately, both international and local efforts demonstrate that this approach is viable. Initiatives such as the Global Green and Healthy Hospitals Agenda promote the adoption of sustainable healthcare practices, while experiences like the “Green Hospitals” program in Colombia have shown that it is possible to reduce environmental footprints without compromising quality of care (León Avendaño, 2019).

Universities and research centers have also begun integrating sustainability into curricula, research agendas, and community engagement programs. Their role is crucial in training professionals with systemic thinking and ethical commitment (Rodríguez López et al., 2023). The transition toward circular, resilient, and inclusive organizational models requires innovation, leadership, and intersectoral collaboration. Environmental sustainability in hospitals is not a luxury, but an urgent necessity that connects human health, social justice, and the preservation of the planet.

In the province of Tucumán, the hospital system at the tertiary level is largely concentrated in the provincial capital, with specialized high-complexity centers located in key territorial hubs. This public infrastructure coexists with a private network of high-complexity providers that complements the overall healthcare system, resulting in heterogeneous levels of environmental commitment among institutions.

The objective of this study is to analyze the current situation and progress in both public and private hospitals in the province of Tucumán within the framework of environmental social responsibility.

Development

State of the Art

At a time when climate change is one of the greatest challenges to public health and global security, healthcare systems find themselves in a difficult position.

While they play a crucial role in safeguarding human health, their environmental footprint is substantial. The impact of healthcare on the environment underscores the urgent need to integrate environmental sustainability into healthcare delivery.

The broader implications of climate change—such as the increasing incidence of heat-related illnesses, respiratory conditions, and vector-borne diseases—place additional pressure on healthcare resources. This reinforces the necessity and urgency of a sustainable transformation within the sector.

Sustainability has become a key factor in hospital management, influencing not only environmental performance but also economic efficiency and institutional competitiveness.

The healthcare sector contributes significantly to global greenhouse gas emissions, which calls for urgent reforms in energy use, waste management, building design, transportation, and food systems.

Hospitals are increasingly focusing on energy-efficient infrastructure, resource optimization, and digitalization to reduce costs while meeting sustainability goals.

Global sustainability objectives indicate that, by 2030, healthcare services should adopt environmentally responsible practices to protect both the planet and human health.

Commitment at the leadership level—along with resource allocation and workforce engagement—is essential to align healthcare operations with sustainability objectives. By prioritizing sustainability, hospitals can achieve long-term economic benefits, improve patient outcomes, and promote healthier, more resilient societies.

Nonetheless, there is limited analysis regarding the actual barriers and facilitators that hospitals face when attempting to align with sustainability goals.

A study by Schwab et al. (2025) explores the implementation of sustainability measures in German hospitals, emphasizing their crucial role in mitigating environmental impacts and promoting public health. Initiatives such as ecological hospital design, sustainable food systems, and green procurement strategies are fundamental to reducing ecological footprints. The authors also offer policy recommendations for decision-makers, hospital administrators, and healthcare professionals to accelerate sustainability initiatives.

Healthcare systems worldwide are increasingly adopting green hospital practices that prioritize environmental and social impacts across institutional operations. Hospitals play a fundamental role in assessing and mitigating the environmental impact of healthcare activities. In a systematic review of 27 articles, Badanta et al. (2025) identified a wide range

of sustainability initiatives rooted in the principles of the circular economy. These include sustainable practices in energy and natural resource use, environmentally friendly transportation solutions, sustainable food procurement, and comprehensive waste management strategies. The authors highlight the crucial role of committed leadership and pro-environmental attitudes among managers and healthcare professionals, who serve as catalysts for fostering more sustainable and environmentally responsible healthcare practices.

Similarly, Oduncu (2023) explains the concept of the green hospital, detailing the characteristics such institutions should have and the goals of a global green and healthy hospital. The study examines the concept of sustainable building design, including the certifications healthcare institutions must obtain and the associated benefits.

Likewise, De Waele et al. (2024) assess the impact of climate change on the operations of intensive care units (ICUs), which require extensive resources and generate significant waste due to energy consumption, disposable materials, and advanced therapies for critically ill patients. To reduce this environmental burden, the authors propose a structured approach for ICUs to reduce their impact by emphasizing energy efficiency, waste reduction, and sustainable procurement. They also stress the need to raise awareness among healthcare professionals, integrate sustainability into research, and implement sustainable policies within scientific societies. Promoting a resilient and environmentally responsible healthcare system is a shared responsibility among all ICU stakeholders.

Climate change has become a public health issue. Carbon footprint assessment is an essential component of the ecological footprint of an institution, measuring the biologically productive land required to produce the goods and services consumed, as well as the capacity to assimilate the waste generated. Estimating a hospital's carbon footprint is therefore crucial to evaluate the environmental impact of its activities.

In Argentina, Smith Rodríguez and de Titto (2018) conducted a study to estimate the carbon footprint of the Enrique Tornú General Hospital in Buenos Aires for the year 2015. Employing a mixed-methods qualitative and quantitative approach, the study analyzed greenhouse gas emissions from hospital activities from an organizational perspective. The results revealed the hospital's environmental impact and its contribution to global warming. Identifying the emissions associated with each activity allowed researchers to pinpoint the most significant sources and potential opportunities for mitigation and reduction strategies. This indicator served as a baseline for measuring progress in programmed emission reductions.

In summary, all referenced authors highlight the need to integrate environmental management into the strategic and operational frameworks of healthcare systems, positioning hospitals as key actors in promoting ecological sustainability within their

communities.

Conceptual framework

In recent decades, the environmental impact of the healthcare sector has become a growing concern, driving the need to rethink hospital management from a sustainability perspective.

In this context, hospital management has increasingly incorporated an ecological approach, promoting the adoption of sustainable operational models.

This new approach to hospital management seeks to protect natural resources, limit environmental impacts, prevent pollution, adopt sustainability-oriented practices, prioritize recycling, manage waste responsibly, use water efficiently, harness renewable energy sources, and ensure that hospital buildings are designed according to sustainable construction criteria.

These so-called green hospitals represent an innovative and urgent response to contemporary climate and health challenges. They are healthcare institutions that minimize their ecological footprint, promote efficient use of energy and resources, and provide a healthy environment for patients, staff, and the surrounding community.

The concept of a green hospital goes beyond sustainable architecture or energy conservation. It entails a comprehensive approach that includes the management of hazardous waste, the selection of non-toxic construction materials, water-use efficiency, healthy food sourcing, sustainable mobility, and environmental education for healthcare workers. This vision aligns closely with the Global Green and Healthy Hospitals Agenda, an initiative led by Health Care Without Harm and the Global Green and Healthy Hospitals Network, which provides a concrete framework for action.

The relevance of the Global Green and Healthy Hospitals Network lies in its ability to coordinate climate adaptation and mitigation strategies within a critical sector. Its steady growth—now surpassing 2,000 members worldwide from 86 different countries—demonstrates its global influence. Membership is notably diverse, including national ministries of health, large private healthcare systems, provincial health departments, and rural clinics. Joining the network implies a formal institutional commitment to the Global Agenda for Green and Healthy Hospitals.

For this study, the concept of a green hospital and the ten objectives of the Global Agenda for Green and Healthy Hospitals were examined, as they constitute the programmatic framework guiding sustainability actions in healthcare institutions. These objectives outline the path toward a healthier, more sustainable, and cost-efficient healthcare system.

The World Health Organization (WHO) issued a global challenge to reduce the environmental impact of the healthcare sector through the development of the Global Green and Healthy Hospitals Agenda. No national or international standard defines green hospitals with such scope.

According to the Global Green and Healthy Hospitals Agenda (2011):

A green and healthy hospital is a facility that promotes public health by continuously reducing its environmental impact and ultimately eliminating its contribution to the burden of disease. A green and healthy hospital recognizes the intrinsic link between human health and the environment, and demonstrates this through its governance, strategy, and operations. It connects local needs to environmental action and advances primary prevention by actively participating in initiatives that promote environmental health, health equity, and a green economy. (p. 6)

Based on this definition, a sustainable hospital—aligned with social, environmental, and economic dimensions of sustainable development—is one that delivers healthcare services in a way that is economically viable, socially responsive to community needs, and environmentally respectful. Since a hospital's ultimate mission is to protect human health, a sustainable hospital must diagnose, treat, and care for patients using natural, energy, and material resources efficiently and with minimal environmental impact.

The management of green hospitals involves the application of policies and procedures aligned with environmentally responsible practices across several areas: hazardous substances, waste management, water conservation, emissions control, and environmentally innovative design.

Around the world, numerous strategies are being implemented to advance green hospital development. For instance, Thailand has defined parameters related to materials, energy, chemical use, and waste generation, while the United Kingdom has developed a “Road Map” for environmentally sustainable healthcare.

The Global Green and Healthy Hospitals Agenda (2011) outlines ten key objectives for hospitals:

1. Leadership

Hospital leadership must guide the transformation toward green and healthy facilities. The leadership objective is based on:

- Promoting cultural change to encourage the participation of hospital staff and the broader community.
- Supporting environmental public health policies.

Key steps include:

- Forming an interdisciplinary sustainability team backed by hospital leadership.
- Encouraging research on environmental sustainability and its health implications.
- Engaging the community by educating both healthcare professionals and the public.
- Advocating for environmental health policies.

2. Chemicals

Replace harmful chemicals with safer alternatives to protect patients, staff, communities, and the environment.

Healthcare is one of the largest consumers of chemicals, including substances with documented adverse health and environmental effects.

3. Waste

Reduce, treat, and safely dispose of healthcare waste to protect public health, decrease toxicity, and implement environmentally sound waste management options.

Medical waste is often classified by risk: Low-risk waste (75–85%) unless incinerated; Infectious waste: general infectious waste, sharps, highly infectious waste, anatomical and pathological waste; Chemical and radioactive waste (3%), including pharmaceuticals, laboratory chemicals, cleaning products, heavy metals (e.g., mercury, lead), and pesticides.

Improper waste disposal can release hazardous chemicals, dioxins, furans, and heavy metals, contributing to pollution and greenhouse gas emissions such as methane.

Hospitals can reduce waste and emissions through better procurement, minimizing packaging, using reusable products, and purchasing recycled materials.

Waste is commonly classified into four groups:

- Group I: waste similar to household waste
- Group II: non-specific healthcare waste
- Group III: high-risk healthcare waste (requiring strict controls and licensed waste managers)
- Group IV: waste subject to special regulations (e.g., cytotoxic, chemical residues, expired medicines, oils, metals, radiological waste, liquids)

4. Energy

Implement energy efficiency and renewable energy systems to reduce reliance on fossil fuels.

Hospitals in Argentina are among the buildings with the highest energy consumption due to heating, cooling, ventilation, lighting, and specialized equipment.

5. Water

Reduce water consumption and ensure access to safe drinking water through conservation technologies, recycling, and wastewater treatment.

Human resources must be trained to adopt water-saving behaviors.

6. Transportation

Improve transportation strategies for patients and staff to reduce the carbon footprint. Transportation accounts for a significant portion of healthcare-sector emissions; in the UK, 18% of NHS carbon emissions are linked to patient and staff travel.

7. Food

Purchase and provide healthy, sustainably grown food. Hospitals should support local food systems and reduce the environmental impact of their food services.

8. Pharmaceuticals

Manage and dispose of pharmaceuticals safely. Measures include reducing unnecessary prescriptions, improving stock management, minimizing improper disposal, and establishing take-back programs.

Sweden classifies pharmaceuticals by environmental impact to support greener prescribing.

9. Buildings

Promote green design and construction in healthcare facilities, considering land use, water and energy consumption, materials sourcing, indoor environmental quality, natural lighting, ventilation, renewable energy, and green roofs.

10. Sustainable Procurement

Purchase environmentally responsible products that minimize impact throughout the life cycle—from raw material extraction to disposal. Hospitals, as major purchasers, can influence markets toward safer and more sustainable products.

Environmental procurement criteria include:

- Life cycle analysis
- Environmental product declarations
- Energy efficiency ratings
- Sustainable raw materials
- Clean manufacturing processes
- Efficient use and durability
- Recyclable end-of-life materials

Ethical and social criteria must also be incorporated (human rights, labor standards, child labor prevention, etc.).

Green hospitals can prevent, mitigate, and compensate environmental and health impacts while advancing sector-wide action plans to minimize risks to human health.

Across Latin America—particularly in Argentina, Colombia, and Brazil—both public and private institutions have begun adopting these strategies, although challenges persist in financing, staff training, and regulatory adaptation.

The transition toward green hospitals requires cultural and organizational transformation, leadership, patient involvement, government support, and intersectoral collaboration. Integrating health and sustainability positions hospitals as key agents promoting environmental and social well-being.

In summary, green hospitals are essential for advancing sustainable and resilient health systems. The Global Agenda offers a clear roadmap and practical tools for healthcare institutions seeking to lead environmental protection and public health promotion. Hospital sustainability is not optional—it is an unavoidable necessity.

Methodology

The purpose of this study is to analyze the current situation and progress made by both public and private hospitals in the province of Tucumán regarding environmental social responsibility.

Tucumán's participation in the Global Green and Healthy Hospitals Network is closely linked to the history and legal framework of its healthcare system, which provides a solid foundation for the adoption of environmental health policies. Established in 1984, the Provincial Health System (SIPROSA) explicitly incorporated the promotion and protection of environmental health among its core functions. This historical precedent positions the Network as a strategic and natural extension of the system's institutional mission.

Despite efforts to identify the presence of Global Green and Healthy Hospitals Network members within the province, a significant limitation was found regarding the availability and transparency of published information. Official directories consulted do not provide updated lists by country or province that would allow for a thorough verification of member institutions, their incorporation dates, or their current membership status. Moreover, institutional communications disseminated through local and national media do not offer systematized data that would allow us to confirm the number of member facilities in Tucumán or compare historical trends. As a result, any estimation of provincial participation must be interpreted with caution. In this study, the impossibility of precisely confirming such figures based on verifiable sources is explicitly acknowledged. While this limitation does not invalidate the

findings presented, it highlights the need for future research to rely on consolidated official records or information provided directly by the Network's coordinating bodies, in order to strengthen the validity and comparability of analyses.

This study employed a mixed-methods approach (qualitative and quantitative), descriptive and cross-sectional in nature. A purposive sample of ten healthcare centers—two from the public sector and eight from the private sector—was selected. All of them are tertiary-level facilities (providing high-complexity diagnostic, therapeutic, and support services requiring advanced technology and specialization) within the province of Tucumán. These institutions were either formally affiliated with, or in the process of aligning themselves to, the Global Green and Healthy Hospitals Network and had adopted the ten objectives of the Global Agenda as their environmental sustainability framework.

Due to confidentiality agreements, the precise identification of the healthcare facilities analyzed cannot be disclosed. Nevertheless, the following table provides details regarding the sector, geographic location, and membership status of each institution in relation to the Global Green and Healthy Hospitals Network.

Table 1
Hospital Sample – March 2025

Case	Sector	Location	Status
1	Public	Capital	Member
2	Public	Capital	Member
3	Private	Interior	In progress
4	Private	Capital	Member
5	Private	Capital	In progress
6	Private	Capital	Member
7	Private	Interior	Member
8	Private	Interior	In progress
9	Private	Interior	In progress
10	Private	Capital	In progress

Note: Authors' elaboration

Membership in the Global Green and Healthy Hospitals Network requires a formal process that includes the submission of an interest form and a letter of intent signed by an institutional authority. The Network distinguishes among various categories (hospitals/health centers, health systems, and health organizations) and provides thematic guidance for each of the ten objectives of the Global Agenda. In practice, membership is often complemented by training activities and participation in regional initiatives (such as "Less Footprint, More Health"), which facilitate experience sharing and the gradual adoption of environmental sustainability measures.

The Network is extensive and diverse, and its membership lists—along with

membership dates—are generally managed through internal platforms. Given the impossibility of accessing an external database to verify formal membership dates by institution, verification in this study was carried out using documents published by the Ministry of Public Health of Tucumán and through an operational verification methodology. This consisted of identifying institutional actions aligned with the terminology and methodology of the Global Green and Healthy Hospitals Agenda, serving as the most robust evidence of active participation.

Data collection was carried out using a structured instrument composed of ten sections corresponding to each of the Network's objectives (leadership, chemicals, waste, energy, water, transportation, food, pharmaceuticals, buildings, and purchasing). The instrument captured both implemented actions and their degree of implementation, categorized as low, medium, or high.

Information was collected in March 2025 through semi-structured interviews with those responsible for environmental management and through a review of institutional documents (plans, policies, internal reports). A comparative matrix of best practices was also developed, allowing for the identification of shared strengths and challenges.

Results

The results reveal uneven progress in the implementation of the ten objectives across the hospitals analyzed. Below is a summary table organized by objective:

Table 2

Adoption of Green Hospital Objectives – March 2025

Objectives	Hospitals implementing actions	Level of implementation
Leadership	8	Medium to High
Chemicals	10	Medium
Waste	10	Medium
Energy	6	Medium
Water	7	Medium
Transportation	2	Low
Food	4	Low to Medium
Pharmaceuticals	6	Medium
Buildings	2	Low
Green Procurement	5	Medium

Note: Authors' elaboration

Summary of Results by Objective:

- Leadership: eight out of the ten facilities have an explicit institutional policy on environmental sustainability, although only three publish annual progress reports. Implementation level: medium to high.
- Chemicals: all hospitals have protocols for handling hazardous substances, although only three have plans for progressive substitution. Implementation level: medium.
- Waste: all facilities implement hazardous waste management systems, yet only five have initiatives for reducing general waste at the source. Implementation level: medium.
- Energy: six hospitals have adopted LED lighting and basic energy efficiency policies; however, only two have incorporated any form of renewable energy. Implementation level: medium.
- Water: seven hospitals use water-saving devices and monitor consumption, although greywater reuse remains limited. Implementation level: medium.
- Transportation: only two hospitals promote sustainable mobility (e.g., bicycle use, carpooling). Implementation level: low.
- Food: four hospitals have reduced single-use plastics in food services and source from local providers when possible. Implementation level: low to medium.
- Pharmaceuticals: six facilities monitor and safely collect expired medicines and antibiotic residues. Implementation level: medium.
- Buildings: only two hospitals have elements of sustainable architecture or hold relevant certifications. Implementation level: low.
- Green Procurement: five institutions have green purchasing policies prioritizing biodegradable and recyclable products. Implementation level: medium.

Table 3*Comparative Matrix of Best Practices and Shared Challenges – March 2025*

Objetivos	Best Practices Identified	Shared Challenges
Leadership	Institutional sustainability policies; environmental committees	Lack of periodic progress reporting
Chemicals	Safe-use protocols; internal training	Absence of chemical substitution programs
Waste	Segregation; differentiated disposal of hazardous waste	Limited planning for waste reduction at the source
Energy	LED installation; energy audits	Low adoption of renewable energy
Water	Water-use monitoring; efficient fixtures	Lack of greywater treatment
Transportation	Bicycle parking; carpool initiatives	Limited adoption of sustainable transport
Objetivos	Best Practices Identified	Shared Challenges
Food	Reduced single-use plastics; local providers	Lack of sustainable food planning
Pharmaceuticals	Collection of expired drugs; inventory control	Weak coordination with laboratories and manufacturers
Buildings	Natural ventilation; green roof planning	Slow progress toward green building certifications
Green Procurement	Sustainable purchasing policies; recyclable products	Limited understanding of life cycle criteria

Note: Authors' elaboration

The comparative matrix demonstrates that, while there is notable progress in areas such as waste management, energy efficiency, and institutional leadership, significant gaps remain across most hospitals. Many facilities have implemented foundational sustainability measures—such as waste segregation and efficient lighting—but lack mechanisms for continuous monitoring, evaluation, and integrated planning.

Common strengths include: institutional environmental policies, initial energy efficiency measures, and proper handling of hazardous waste. Common challenges include: limited adoption of sustainable transport, insufficient wastewater treatment, slow development of green infrastructure, and weak sustainability practices in supply chain coordination.

These findings underscore the need for strategic planning, continuous staff training, and a strengthened institutional commitment to a measurable, system-wide sustainability culture.

In line with the “Shared Challenges” identified in Table 3, the following integrative guidelines are proposed to support capacity building, monitoring, and inter-institutional coordination:

- Institutionalize periodic progress reports to strengthen transparency and monitoring.
- Develop multi-year programs for the substitution of priority chemicals, supported by Global Network guidelines.
- Prioritize green procurement and life-cycle assessments to reduce waste generation at the source.
- Promote pilot projects on renewable generation (solar panels, LED retrofits) and energy audits with incremental targets.
- Launch pilot initiatives for greywater reuse and establish agreements with treatment service providers.
- Design sustainable mobility policies for the workforce (carpooling, bicycle incentives) and sustainable local food purchasing plans.
- Establish formal agreements with manufacturers for safe pharmaceutical returns and disposal.
- Encourage progressive certification of green infrastructure and strengthen continuous staff training.

These measures align with practical guidance from the Global Green and Healthy Hospitals Network and contemporary scientific literature on hospital sustainability. Each recommended action should include baseline indicators and measurable targets to ensure traceability of progress.

CONCLUSION

The analysis of these ten healthcare centers in Tucumán reveals an emerging yet steadily growing awareness of environmental issues within the health sector—an awareness that is beginning to manifest in concrete actions aligned with the goals of green hospitals. While some areas, such as waste management and energy efficiency, show notable progress, others—such as sustainable transportation, food management, and green infrastructure—remain underdeveloped.

Adopting the green hospital approach is essential not only for reducing the sector’s ecological footprint but also for strengthening the connection between human health and environmental health. By doing so, healthcare institutions foster more integrated and resilient models of care. However, the path ahead is considerable, particularly given that many public

institutions in the province have yet to integrate these principles into their policies and operational practices.

Both the public and private sectors must commit to incorporating environmental sustainability as a strategic priority. This requires concrete action plans, impact measurement, and transparent reporting. Such efforts are fundamental to building healthcare systems that not only heal but also care for the environment upon which the health of individuals and communities depends.

REFERENCES

Please refer to the articles in Spanish Bibliography.

BIBLIOGRAPHICAL ABSTRACT

Please refer to articles Spanish Biographical abstract.