A Framework to Reduce Greenhouse Gas Emissions in U.S. Hospitals: The C6 Strategy

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Abstract

Background

Healthcare is responsible for approximately eight percent of the United States' greenhouse gas emissions (Eckelman et al., 2020). Hospital operations are resource-intensive and can conflict with the mission to heal by creating environmental externalities that affect patients, staff, and surrounding communities. Recent climate-related disasters, such as Hurricane Helene and the California wildfires, have revealed the cascading risks that threaten hospital operations, patient safety, and community resilience (Baxter, 2024; Chief Healthcare Executive, 2025).

Objectives

This study presents and operationalizes the C6 Framework, Connect, Collect, Combat, Correct, Communicate, and Clear, as a person-centered strategy for integrating climate action and resilience into U.S. hospital operations. The objective is to provide an adaptable, measurable, and human-focused model that addresses Scopes 1, 2, and 3 emissions while strengthening organizational culture and equity.

Methods

The framework was developed through a synthesis of peer-reviewed literature. Evidence was drawn from examples including Boston Medical Center, Cleveland Clinic, Emory Healthcare, Rush University Medical Center, Tampa General Hospital, and the University of Pittsburgh Medical Center (Boston Medical Center, 2023; Emory Healthcare, 2023; Tampa General Hospital, 2024; UPMC, 2023). Behavior change principles from the transtheoretical model guided the integration of individual and organizational engagement (Prochaska & Velicer, 1997).

Results

The C6 Framework translates sustainability into person-centered practice by linking climate action to patient healing, staff well-being, and community health. Documented results associated with C6 aligned interventions include:
 Emissions reductions and savings: Boston Medical Center reduced emissions by 91% while

generating over $40 million in annual savings, with $8 million reinvested in patient care (Boston Medical Center, 2023).

Behavioral engagement: At the 2023 One Healthcare Ecochallenge, nearly 2,500 healthcare employees from systems such as the Cleveland Clinic and Mayo Clinic logged more than 35,000 sustainable actions, demonstrating scalable engagement (Practice GreenHealth, 2024).

Operational resilience: Tampa General Hospital maintained uninterrupted operations during major hurricanes by deploying advanced resilience infrastructure such as its elevated central energy plant and AquaFence system (Tampa General Hospital, 2024). Clinical interventions: Replacing desflurane and nitrous oxide with lower-impact anesthetics reduced operating room emissions by nearly 50% and generated significant cost savings (Eckelman et al., 2020; Healthcare Without Harm, 2020).

Energy efficiency: UPMC's energy audits led to targeted upgrades, including chiller optimization and LED retrofits, yielding over $1 million in savings and improved patient comfort within four years (U.S. Department of Energy, 2012; UPMC, 2023).

Conclusions

The C6 Framework provides a practical, person-centered pathway for hospitals to reduce greenhouse gas emissions while advancing resilience and health equity. By connecting people to purpose, collecting meaningful data and stories, combating organizational barriers, correcting systems with supportive tools, communicating transparently, and clearing structural obstacles to adoption, hospitals can achieve measurable decarbonization, realize financial returns, and safeguard patient care in the face of climate change (Eckelman et al., 2020; Etzel et al., 2024).

Introduction

Healthcare facilities are designed to serve as a safe haven for patients, yet contribute significantly to environmental harm. Hospitals are energy-intensive buildings that operate continuously to support critical care, research, and community health needs (Vaziri et al., 2020). This demand results in substantial greenhouse gas emissions, waste generation, and resource depletion. Although the environmental demands of healthcare promote optimal care delivery, an unintended consequence, or externality, is the damage to built environments. Patients recovering in urban hospitals face greater risks from heat islands and poor air quality. Communities bear the consequences of both pollution and service interruptions when climate events overwhelm healthcare systems.

Recent disasters underscore this vulnerability. Hurricane Helene, for example, not only resulted in 241 deaths but also disrupted the Baxter International plant, the nation's largest manufacturer of intravenous fluids, leading to rationing, alternative hydration methods, and a federal response that produced 7,500 metric tons of carbon emissions (Baxter, 2024). Similarly, wildfires in California displaced families while threatening hospitals located within a mile of high fire-risk zones (Chief Healthcare Executive, 2025). These events demonstrate how climate disruptions create cascading consequences for patients, clinicians, and communities who depend on reliable care.

To address this reality, healthcare organizations must adopt sustainability and resilience as core strategic objectives, rather than transient goals. Emissions are commonly categorized into three scopes: Scope 1 (direct, on-site emissions), Scope 2 (indirect emissions from purchased energy), and Scope 3 (indirect emissions across the supply chain). Scope 3 remains the most difficult to manage due to its reliance on complex procurement systems and global suppliers. The C6 framework highlights the importance of intervention in scope 1.

Existing frameworks and models in the literature often concentrate on narrow dimensions, varying in complexities such as buildings (de Fátima Castro et al., 2017), waste processing and management (Hassan et al., 2022; de Aguiar Hugo et al., 2021; Li et al., 2021), product and process design (Morell-Santandreu et al., 2021), or human resources management (Mousa et al., (2020; Pinzone et al., 2016). The C6 Framework advances the field by integrating behavioral change, operational efficiency, and resilience planning into a single, person-centered strategy that is both measurable and adaptable across healthcare settings.

The C6 Framework offers a pathway to integrate climate action into healthcare strategies with a human-centered focus. By connecting teams, collecting meaningful data and stories, addressing behavioral and organizational barriers, refining systems to facilitate sustainable practices, communicating clearly, and removing obstacles for staff and patients, the framework prioritizes people at the center of climate resilience.

The impact of healthcare organizations varies by size. Larger hospitals have footprints that can be over 100,000 metric tons of Carbon Dioxide emissions annually, which is roughly equivalent

to the weight of a large cruise ship. Additionally, specialty hospitals and units have higher per-bed emissions. Emissions from intensive care units (ICUs) average approximately 138 kg CO2e per bed-day, more than three times higher than those from acute inpatient units, which average 45 kg CO2e per bed-day (Prasad et al., 2020).

The C6 Framework

Connect

The transtheoretical model, developed by Prochaska and DiClemente, describes behavior change as a dynamic process in which individuals move through sequential stages, precontemplation, contemplation, preparation, action, and maintenance, while adopting healthier or more sustainable behaviors (Prochaska & Velicer, 1997). Connecting teams through the transtheoretical model of behavioral change begins with the pre-contemplation phase, where awareness is minimal. Once awareness occurs, the contemplation phase begins, subsequently preparation and action follow, and lastly maintenance occurs to ensure longevity of the behavior change.

Pre-Contemplation phase

Visual aids, illustrating the impact of improper waste disposal and the benefits of recycling, can spark curiosity and awareness.

Contemplation

Introducing pledges or competitions can foster commitment. The Mayo Clinic, the Cleveland Clinic, and PeaceHealth have gamified sustainability, enabling employees to earn points for taking sustainable actions and contributing to their organization's overall sustainability efforts. During the inaugural 2023 One Healthcare Ecochallenge, nearly 2,500 healthcare employees from these and other organizations logged more than 35,000 sustainable actions via the online platform. Cleveland Clinic teams alone completed more than 15,000 environmentally beneficial actions during the challenge, providing motivation, reinforcing positive habits, and facilitating meaningful connections among colleagues (Practice GreenHealth, 2024). The approach received overwhelmingly positive feedback, evidencing an increase in engagement and lasting changes in workplace sustainability behaviors.

Preparation

Green teams comprising subject matter experts and enthusiastic volunteers guide and educate staff. The governance of a green team is portrayed in Figure 1. In the action phase, expressing gratitude and ensuring enjoyable sustainability activities, such as competitions involving family and friends, are crucial for behavior modification. At Emory Healthcare, the green team collaborated with procurement and surgical staff to pilot a single-use device reprocessing program. Devices such as compression sleeves and catheters were collected, sterilized, and

safely reused in accordance with FDA standards. The initiative diverted more than 10 tons of waste annually and saved the system over $2 million in supply costs, while also strengthening staff confidence in environmentally responsible clinical practices (Emory Healthcare, 2023).

Action

Prompting teams to take action is most effective through in-person strategic planning sessions that encourage active participation and information sharing. Each attendee's insights can be incorporated and distilled using decision-making tools such as the Stacey matrix, which helps groups categorize complex sustainability challenges based on levels of certainty and agreement. The matrix supports teams in identifying whether problems are simple, complicated, complex, or chaotic, and guides the selection of appropriate management and planning strategies in dynamic healthcare environments (AgilityPortal, 2024). This approach ensures that sustainability initiatives align with operational realities, stakeholder perspectives, and the unpredictable nature of healthcare systems, leading to more adaptive and robust climate action plans.

Maintenance

To sustain momentum, positive reinforcement should be provided through awards, public recognition, and the sharing of data. Reminding team members of the importance of reducing the organization's carbon footprint and inviting them to share their motivations further strengthens engagement.

Facilitating a culture shift starts with individuals who are passionate about environmental stewardship. Social media, conversations, and sustainability events can build this culture. Leadership and governance are essential; establishing green teams and sustainability leaders embed these values into the organization's fabric. Practice Greenhealth has identified that a green squad and social groups will assist in guiding and educating team members in the planning stage (Practice GreenHealth, 2008). Informal brainstorming and addressing grievances help overcome barriers.

Collect

Data collection is the first step toward environmental change. In 2022, 370 hospitals collectively saved more than $197.4 million through sustainability initiatives (Practice GreenHealth, 2023). Reporting should align with strategic goals. Kaiser Permanente, for example, achieved a 29% reduction in greenhouse gas emissions from 2008 to 2018 by setting explicit goals and measuring performance(Hensher et al., 2020).

Key data points include energy usage, waste production, water usage and source, greenhouse gas emissions, supply chain practices, anesthetic gases, vehicle fleets, and local green spaces.

Combat

A major challenge in advancing healthcare sustainability is overcoming skepticism about clinician engagement, financial return, and the scalability of these initiatives. Clinicians often perceive sustainability as peripheral to patient care, while administrators question long-term savings. Addressing these barriers requires framing environmental initiatives as integral to the mission of healing, improving workplace conditions, and strengthening community trust (Etzel et al., 2024).

Boston Medical Center (2023) provides a compelling blueprint. By explicitly linking sustainability to its mission of healing and community health, BMC reframed environmental stewardship as a clinical issue. This alignment increased clinician buy-in by demonstrating how reduced exposure to anesthetic gases and resilient infrastructure directly affect patient outcomes. BMC reduced energy use by 35 percent and carbon emissions by 91 percent, producing more than $40 million in annual operational savings, with $8 million reinvested in patient care (Boston Medical Center, 2023).

Clinician attitudes reflect this growing alignment. A 2023 Commonwealth Fund survey found that four in five U.S. healthcare workers believe their organizations should prioritize environmental stewardship because of its impact on patient health (Commonwealth Fund, 2023).

A robust Combat strategy also requires consistent oversight. Regular audits of energy, water, and supply chain practices ensure progress is sustained.

The University of Pittsburgh Medical Center (UPMC) was an early adopter in energy audits, forming a partnership with the U.S. Department of Energy in 2008, and has continued this momentum by sharing benchmarks with the public. Today, through energy audits, UPMC identified and implemented targeted upgrades such as chiller optimization, variable air volume controls, air balancing, LED lighting retrofits, occupancy sensors, and improved building automation systems, which together reduced energy use, improved air quality, and created safer, more comfortable environments for patients and staff.

These interventions not only reduced energy consumption and operating costs but also enhanced indoor air quality and comfort for patients and staff, addressing the dual goals of environmental stewardship and clinical well-being (U.S. Department of Energy, 2012; UPMC, 2023).

Together, these examples highlight that the key to overcoming skepticism lies in making the human benefits of sustainability visible: healthier patients, safer working environments, and stronger community resilience (Eckelman et al., 2020).

Targeted interventions can deliver significant environmental, financial, and human health benefits. Hospitals that integrate sustainability into operations not only lower emissions but also create healthier environments for patients, staff, and surrounding communities.

Facility Operations

LED retrofitting and motion-sensor lighting can reduce lighting-related energy consumption by up to 70%, lowering costs and creating brighter, safer spaces for staff working night shifts (Practice GreenHealth, 2023).

Energy audits and upgrades at institutions like the University of Pittsburgh Medical Center (UPMC) identified opportunities such as chiller optimization, variable air volume controls, air balancing, and improved building automation systems, leading to over $1 million in savings within four years and enhanced air quality in patient care areas (U.S. Department of Energy, 2012; UPMC, 2023).

Renewable energy investments, such as solar carports and virtual power purchase agreements, have been adopted by Boston Medical Center, AdventHealth, and Kaiser Permanente to stabilize energy costs and reduce Scope 2 emissions (Boston Medical Center, 2023). Virtual power purchase agreements (VPPAs) allow hospitals to contract for renewable energy generation without owning or operating the facility, providing financial stability while reducing reliance on fossil fuels.

Clinical Practice

Anesthetic gases such as desflurane and nitrous oxide are potent greenhouse gases, with global warming potentials of 2,540 and 298 times that of carbon dioxide, respectively (IPCC, 2013; as reported in Eckelman et al., 2020)

Replacing desflurane with lower-impact alternatives, such as sevoflurane or isoflurane, can reduce operating room emissions by nearly 50%. Additionally, nitrous oxide can often be eliminated or replaced with intravenous anesthetics, resulting in significant environmental and cost savings. The Virginia Mason Medical Center has saved more than $30,000 each year since replacing desflurane and nitrous oxide (Healthcare without Harm, 2020).

Supply Chain

Standardizing operating room supply packs and eliminating consistently unused items can reduce per-procedure costs by 15–30% while minimizing medical waste (Practice GreenHealth, 2023).

Revising procurement contracts to include sustainability criteria ensures suppliers adopt environmentally responsible practices.

Donating surplus materials supports global health while preventing waste from entering landfills. Organizations like MedShare and MATTER recover millions of pounds of surplus medical materials each year that would otherwise be discarded. Repurposing usable items reduces the environmental impact associated with the manufacturing, transportation, and disposal of new medical products. Donating surplus materials reduces Scope 3 emissions by avoiding the

upstream ecological burden of manufacturing and transporting new medical products, while also reducing downstream disposal-related emissions (Practice GreenHealth, 2023).

Community and Well-Being

Hospital-supported community gardens provide staff and patients with access to fresh produce while reducing the carbon footprint of food procurement.

Arbor Day tree-sharing and shaded recovery spaces extend health benefits beyond hospital walls, lowering heat stress risks and enhancing recovery environments (Etzel et al., 2024).

Trees benefit both mental and physical health. Spending time among them reduces stress and anxiety, lowers blood pressure, and enhances mood. Additionally, simply viewing nature from a hospital window can accelerate postoperative recovery (U.S. Department of Agriculture Forest Service, 2024). Furthermore, a 2021 study by the University of Michigan found that exposure to natural environments alleviated symptoms of depression and anxiety in children and adolescents (Groundwork USA, 2024)

Expanding green space on hospital grounds has been linked to faster patient recovery times and improved employee satisfaction, strengthening the connection between environmental stewardship and clinical outcomes. (Iperen et al., 2023)

Accountability and Resilience

A comprehensive audit should measure energy use, water consumption, waste generation, greenhouse gas emissions (Scopes 1–3), and supply chain practices. Over 370 hospitals saved $197 million in a single year by tracking these indicators through Practice GreenHealth benchmarking (Practice GreenHealth, 2023).

Embedding environmental, social, and governance (ESG) standards provides structure for reporting, while real-time dashboards support transparency and accountability across staff and leadership (Forbes Business Council, 2023).

Tampa General Hospital (TGH) demonstrates resilience planning: a Central Energy Plant constructed 33 feet above sea level ensures reliable power during Category 5 hurricanes; an AquaFence barrier protects 15 feet of storm surge; and continuous training prepares staff to maintain operations. These investments enable TGH, as the region's only Level I Trauma Center, to deliver uninterrupted care during extreme climate events (Tampa General Hospital, 2024).

Communicate & Clear the Path Forward

Clarity is a significant barrier to implementing sustainability initiatives. Effective communication ensures that all stakeholders understand goals, expectations, and their roles. Precise, concise messaging fosters alignment, reduces misunderstandings, and drives collaboration. Regular updates and transparent reporting sustain momentum and reinforce the value of team efforts.

Setting clear expectations and goals is essential. Sustainability initiatives should be measurable and attainable, with goals published in accessible locations and progress updated regularly. As green teams grow, roles should be specified, and incentives and recognition should be provided to maintain momentum. Reviewing the scope's impact at the end of each strategic planning period identifies areas for improvement and informs future strategy (Eckelman et al., 2020; Forbes Business Council, 2023; Health Affairs, 2020).

Effective communication is integral to the success of sustainability initiatives at both the Cleveland Clinic and Kaiser Permanente. Cleveland Clinic actively shares progress toward its carbon-neutral goals through transparent public reporting and internal dashboards, fostering staff engagement and accountability (Utech, 2017). Kaiser Permanente complements its measurable targets with clear, consistent messaging to employees, patients, and stakeholders about sustainability priorities and achievements, using multiple channels such as town halls, newsletters, community outreach, and educational programs (Kaiser Permanente, 2024; Kaiser Permanente, 2023). This transparent, inclusive communication fosters a culture of environmental stewardship, motivates ongoing participation, and aligns diverse stakeholders around shared climate and health goals (Kaiser Permanente, 2025; Commons et al., 2023).

Data visualization tools, such as Tableau and Power BI, present a significant opportunity to connect environmental sustainability initiatives to patient communities through compelling storytelling.

Potential key performance indicators have been grouped below:

Facility Operations

● Energy Use Intensity (EUI): Kilowatt hours per square foot per year, benchmarked against ENERGY STAR healthcare facilities (UPMC Northwest scored 83 in 2022).

● Carbon Emissions per Bed: Metric tons of carbon emissions per occupied bed, allowing comparisons across hospital sizes (Eckelman et al., 2020).

● Percentage Renewable Energy Purchased/Generated: Share of total energy supplied through renewables (Boston Medical Center reports >40% renewable energy).

Clinical Practice

● Anesthetic Gas Consumption: Kilograms of desflurane, sevoflurane, or nitrous oxide used per operating room per year (Practice GreenHealth tracking).

● Greenhouse Gas Equivalency: Converting anesthetic usage to carbon equivalents
Supply Chain

● Sustainable Procurement Rate: Percentage of contracts that include environmental or social responsibility criteria.

● Waste Diversion Rate: Share of waste diverted from landfills through recycling, reprocessing, or donation.

Community and Well-Being

● Patient Recovery Metrics: Average length of stay reductions associated with exposure to natural light or gardens.

● Employee Engagement Scores: Staff satisfaction or retention linked to participation in sustainability initiatives (Commonwealth Fund, 2023).

Accountability and Governance

● Annual Savings from Sustainability Initiatives: Dollar savings reported (e.g., 370 hospitals collectively saved $197 million in one year).

● GHG Reduction Progress Toward Targets: % progress toward system goals (e.g., UPMC's goal of 50% reduction by 2030, net-zero by 2050).

● Public Reporting Frequency: Annual ESG or sustainability report publication, demonstrating transparency.

Conclusion

Incorporating sustainability and climate resilience into healthcare strategy is not only compatible with, but also essential to, the mission of healing. The C6 Framework, Connect, Collect, Combat, Correct, Communicate, and Clear, offers a person-centered pathway to operationalize this alignment. By connecting people to purpose, collecting meaningful data and stories, overcoming barriers to change, refining systems with supportive tools, communicating progress clearly, and clearing the path for long-term adoption, healthcare organizations can reduce emissions, safeguard patient health, and enhance community resilience.

Hospitals that embed these strategies demonstrate measurable benefits, including reduced greenhouse gas emissions, improved indoor air quality, enhanced staff satisfaction, and multimillion-dollar annual savings that can be reinvested into patient care. For example, Boston Medical Center achieved a 91% reduction in emissions, resulting in $8 million in yearly savings that were reinvested in clinical services. At the same time, UPMC's energy audits identified upgrades that improved both efficiency and patient comfort. These cases highlight the dual return on investment, environmental and financial, when sustainability is treated as a strategic imperative.

Looking forward, health systems should establish clear targets, such as reducing facility energy use by 25% within five years or phasing out desflurane by 2026, while piloting scalable innovations that can be shared across the sector. Embedding equity considerations is also critical: communities most affected by climate change often face health disparities, and sustainable

healthcare must advance both resilience and justice. By adopting the C6 Framework, healthcare leaders can transform climate action from an external obligation into a core strategy that protects patients, empowers staff, and positions hospitals as anchors of community well-being in a warming world.

Appendix

Figure 1: Healthcare's Impact Quantified

Hospital Type / Size	Primary Emission Sources	Targeted Reduction Strategies
Small Community Hospital (<100 beds)	Purchased electricity, heating/cooling, medical waste, and fleet vehicles	Conduct energy audits and retrofit with LED lighting and low-flow fixtures (U.S. Department of Energy, 2012; Practice GreenHealth, 2023). Adopt shared procurement contracts to access greener supply options (Practice GreenHealth, 2023). Replace diesel shuttle/fleet with EVs or hybrid vans (U.S. Environmental Protection Agency, 2023). Implement waste segregation and recycling programs with staff education (Practice GreenHealth, 2017).
Medium-Sized Regional Hospital (100-300 beds)	HVAC energy demand, anesthetic gases, laboratory services, supply chain	Transition to renewable energy power purchase agreements or solar carports (Boston Medical Center, 2023). Phase out desflurane and nitrous oxide in operating rooms (Eckelman et al.,

		2020; Etzel et al., 2024). Optimize laboratory operations with energy-efficient freezers and autoclaves (Hensher & McGain, 2023). Partner with suppliers for ESG-aligned purchasing and reduced packaging (Forbes Business Council, 2023).
Large Urban Hospital (300-500 beds)	Surgical services, diagnostic imaging, logistics, and inpatient demand	Install combined heat and power (CHP) systems for efficiency and resilience (Sustainability.com, 2023) Standardize surgical packs to reduce unused items by 15-30% (Practice GreenHealth, 2023). Invest in building automation systems for HVAC and lighting optimization (UPMC, 2023). Adopt circular economy practices for imaging equipment and electronics (Singh, 2024).
Academic Medical Center (>500 beds)	24/7 operations, advanced research labs, supply chain, energy-intensive equipment	Establish campus-wide microgrids integrating renewables and battery storage (Kaiser Permanente, 2023; Sustainability.com, 2023). Create sustainable procurement policies for

		pharmaceuticals and devices (Practice GreenHealth, 2023). Expand green lab certification programs to reduce research energy use (Hensher & McGain, 2023). Embed sustainability into medical education and research funding criteria (NAM, 2023).
Specialty Hospital (Children's, Oncology, etc.) (100-300 beds)	Operating rooms, specialized pharmaceuticals, imaging, and research	Implement anesthetic gas capture and recycling systems (Eckelman et al., 2020). Procure low-carbon pharmaceuticals where alternatives exist (Etzel et al., 2024). Increase reliance on telemedicine for follow-ups to reduce patient travel (Chief Healthcare Executive, 2025). Develop healing gardens and green spaces to offset Scope 1 and 2 impacts while improving patient recovery (Etzel et al., 2024).

Figure 2 (Tampa General Hospital, 2024)

Year	Event / Investment	Key Details
2022	Central Energy Plant	Four-story plant built 33 feet above sea level, providing 100% redundant power during outages
2023	Hurricane Idalia	Hospital remained fully operational; AquaFence successfully prevented storm surge flooding, and power remained on
September 2024	Hurricane Helene	Hospital deployed AquaFence and activated preparedness measures to ensure continuity of operations
October 2024	Hurricane Milton	Implemented a comprehensive mitigation plan; the hospital remained open and fully operational during the storm
2025	Storm-Readiness Infrastructure	On-site emergency water well, substantial fuel reserves, and trained staff maintain operational resilience

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Bibliography

1. American Medical Association. (2024). Fixing the IV fluid shortage is only the start of addressing the drug supply.
https://www.ama-assn.org/delivering-care/public-health/fixing-iv-fluid-shortage-only-start-addressing-drug-supply

2. Baxter. (2024). Hurricane Helene updates.
https://www.baxter.com/baxter-newsroom/hurricane-heleneupdates

3. Boston Medical Center. (2023). Sustainability at BMC.
https://www.bmc.org/sustainability

4. Chief Healthcare Executive. (2025, February 18). For hospitals, building resilience around climate change is not optional.
https://www.chiefhealthcareexecutive.com/view/for-hospitals-building-resilience-around-climate-change-isn-t-optional-vive-2025

5. Chiarini, A., & Vagnoni, E. (2016). Sustainable healthcare: The case of the Italian NHS. Sustainability, 8(4), 317. https://doi.org/10.3390/su8040317

6. Commonwealth Fund. (2023). Clinician perspectives on climate and health.
https://www.commonwealthfund.org/publications/issue-briefs/2024/jan/us-health-care-workers-want-employers-address-climate-change

7. Aguiar Hugo, F., et al. (2021). Waste management practices in healthcare. Journal of Cleaner Production, 328, 129515. https://doi.org/10.1016/j.jclepro.2021.129515

8. Fátima Castro, M., et al. (2017). Hospital buildings and environmental impact. Journal of Environmental Management, 204, 565–580.
https://doi.org/10.1016/j.jenvman.2017.09.026

9. Emory Healthcare. (2023). Sustainability initiatives.
https://www.emoryhealthcare.org/sustainability

10. Etzel, R. A., Weimann, E., Homer, C., Arora, N. K., Maimela, G., Prats, E. V., & Banerjee, A. (2024). Climate change impacts on health across the life course. Journal of Global Health, 14, 03018. https://doi.org/10.7189/jogh.14.03018

11. Fathollahi-Fard, A. M., et al. (2022). Green healthcare operations management: A comprehensive review. Journal of Cleaner Production, 371, 133610.
https://www.sciencedirect.com/science/article/abs/pii/S0959652625002008

12. Forbes Business Council. (2023, December 6). Sustainability communication and credibility: Navigating the path to a greener future. Forbes.
https://www.forbes.com/councils/forbesbusinesscouncil/2023/12/06/sustainability-communication-and-credibility-navigating-the-path-to-a-greener-future

13. Franco, A., et al. (2017). Energy efficiency in hospitals: A review. Renewable and Sustainable Energy Reviews, 75, 809–816. https://doi.org/10.1016/j.rser.2016.11.058

14. García-Sanz-Calcedo, J., & Gómez-Chaparro, M. (2017). Improving energy efficiency in hospitals. Energies, 10(11), 1784. https://doi.org/10.3390/en10111784

15. Groundwork USA. (2024). Nature and health outcomes for children.
https://groundworkusa.org/nature-health-children

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16. Gupta, M. C., & Sharma, K. (1996). Environmental operations management: An integrated approach. Production and Inventory Management Journal, 37(3), 56–62.

17. Hassan, J., et al. (2022). Healthcare waste management and sustainability. Waste Management & Research, 40(12), 1612–1622. https://doi.org/10.1177/0734242X221134468

18. Healthcare without Harm. (2020). Reducing anesthetic gas emissions. https://noharm-uscanada.org

19. Hensher, M., & McGain, F. (2023). Health care sustainability metrics: Building a safer, low-carbon health system. The Medical Journal of Australia, 219(9), 412–414. https://www.healthaffairs.org/doi/10.1377/hlthaff.2020.01103

20. Iperen, J. van, et al. (2023). Green space impacts on hospital recovery. Environmental Research, 218, 114784. https://doi.org/10.1016/j.envres.2022.114784

21. IPCC. (2013). Climate change 2013: The physical science basis. https://www.ipcc.ch/report/ar5/wg1/

22. Jain, S., et al. (2021). Energy use in healthcare facilities. Sustainable Cities and Society, 69, 102820. https://doi.org/10.1016/j.scs.2021.102820

23. Kaiser Permanente. (2023). Sustainability report. https://about.kaiserpermanente.org

24. Li, S., et al. (2021). Recycling and waste management in hospitals. Resources, Conservation, and Recycling, 178, 106057. https://doi.org/10.1016/j.resconrec.2021.106057

25. Morell-Santandreu, O., et al. (2021). Environmental impacts of medical devices. Science of the Total Environment, 788, 147923. https://doi.org/10.1016/j.scitotenv.2021.147923

26. Mousa, M., et al. (2020). Human resource management and sustainability in healthcare. Journal of Cleaner Production, 243, 118668. https://doi.org/10.1016/j.jclepro.2019.118668

27. NAM (National Academy of Medicine). (2023). Key actions to reduce greenhouse gas emissions by U.S. hospitals and health systems. https://nam.edu/product/key-actions-to-reduce-greenhouse-gas-emissions-by-u-s-hospitals-and-health-systems/

28. Nunes, B. (2011). Environmental performance measurement in hospitals. Management of Environmental Quality, 22(3), 352–363. https://doi.org/10.1108/14777831111123425

29. Pinzone, M., et al. (2016). Human factors in green hospitals. International Journal of Environmental Research and Public Health, 13(12), 1222. https://doi.org/10.3390/ijerph13121222

30. Prasad, D., et al. (2020). Carbon emissions in intensive care units. Intensive Care Medicine, 46, 354–356. https://doi.org/10.1007/s00134-019-05842-6

31. Prochaska, J. O., & Velicer, W. F. (1997). The transtheoretical model of health behavior change. American Journal of Health Promotion, 12(1), 38–48. https://doi.org/10.4278/0890-1171-12.1.38

32. Practice GreenHealth. (2008). Green squads and social groups for sustainability in healthcare. https://practicegreenhealth.org/sites/default/files/pubs/epp/GuideGreenTeams.pdf

33. Practice GreenHealth. (2017). Green teams: A guide to effective teams. https://practicegreenhealth.org/sites/default/files/pubs/epp/GuideGreenTeams.pdf

34. Practice GreenHealth. (2023). Sustainability initiatives and savings report. https://practicegreenhealth.org/tools-and-resources/2023-sustainability-data#:~:text=The 370 hospitals that contributed,%24939.7 million in sustainable spending.

35. Sarkis, J. (2017). Green operations management. In Greening logistics: Theory, practice, and future directions (pp. 73–96).

36. Singh, A. (2024). Sustainability practices in business operations. International Journal for Research Publication and Seminar, 15(3), 18–34. https://doi.org/10.36676/jrps.v15.i3.1424

37. Silverthorne, S. (2021). Sustainability assessment in healthcare. Journal of Healthcare Management, 66(1), 17–27.

38. Sustainability.com. (2023). Targeting value: Achieving decarbonization. https://www.sustainability.com/globalassets/sustainability.com/thinking/pdfs/sa-es-targetingvalue.pdf

39. Tampa General Hospital Implements Comprehensive Mitigation Plan to Prepare for Hurricane Milton. (2024, October 8). https://www.tgh.org/news/tgh-press-releases/2024/october/tampa-general-hospital-implements-comprehensive-mitigation-plan-prepare-hurricane-milton

40. Tampa General Hospital stands strong against Milton and remains open to support the community in the aftermath. (2024). https://www.tgh.org/news/tgh-press-releases/2024/october/tampa-general-hospital-stands-strong-against-milton-remains-open-support-community-aftermath

41. UPMC (University of Pittsburgh Medical Center). (2023). Energy management case studies. https://www.upmc.com

42. U.S. Department of Agriculture Forest Service. (2024). Health benefits of trees. https://www.fs.usda.gov

43. U.S. Department of Energy. (2012). Energy efficiency in health care facilities. https://www.energy.gov

44. U.S. Environmental Protection Agency. (2023). Sources of greenhouse gas emissions. https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

45. Utech, J. (2017). Cleveland Clinic makes carbon-neutrality its newest sustainability goal. https://www.hfmmagazine.com/articles/3210-cleveland-clinic-makes-carbon-neutrality-its-newest-sustainability-goal