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Green Telehealth: A Sustainability-Driven Framework for Low-Carbon Digital Health Systems

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Abstract

The global rapid embrace of telehealth has transformed accessibility and effectiveness in healthcare but has consequent implications for the environment. Digital consultations allow for decreased emissions from patient travel, but the infrastructure that supports it: Information and Communications Technology (ICT) including data centers, cloud networks and medical devices, has a significant impact on energy usage. This paper provides a Green Telehealth Framework (GTF) which seeks to allow technological efficiency, operational sustainability and policy cohesion to help enable low carbon digital health ecosystems. The GTF is constructed from studies in sustainability and digital transformation across a number of disciplines and addresses the environmental severity of telehealth through methods including optimizing design, improving renewable energy ICT and promoting sustainable policy instruments. Real world case study applications from the United Kingdom, Australia and the United Arab Emirates demonstrate its practical viability and cost benefit. The comparative study undertaken shows that there may be an energy usage reduction of up to 30% and significant long-term cost savings. Finally, certain recommendations are provided to help telehealth include sustainability as a measurable dimension of the quality of telehealth which promotes the vision of climate-resilient digital health systems.

Keywords

Telehealth, Green ICT, Sustainability, E-Health, Carbon Footprint, Digital Transformation, Health Governance, Environmental Policy

1. Introduction

1.1. Background

Telehealth is one of the most innovative developments in modern healthcare, ena-

bling remote consultations and continuous health monitoring through digital networks. The COVID-19 pandemic has meant that telehealth has seen a dramatic increase by approximately 400% within OECD (Organisation for Economic Co-operation and Development) countries in the use of telemedicine services within the provision of healthcare worldwide (OECD, 2019). However, this innovation in the delivery of healthcare has also presented a sustainability dilemma. Telemedicine reduces the emissions associated with trips taken by people to access consultations but increases the energy consumption associated with the need for data-intensive activities. The requisite infrastructure, from cloud servers to IoMT devices, contributes to the incremental digital carbon footprint (World Health Organization, 2024). There is evidence to suggest that healthcare generates approximately 4% - 5% of global emissions of greenhouse gases, with a growing proportion of these coming from the digital systems (Thiel et al., 2023). While telehealth increases efficiency, it also increases the energy demands of data centers and electronic lifecycles (International Energy Agency, 2024). Yet, in spite of these trends sustainability in telehealth has received little attention in health policy making. The environmental agendas of traditional hospitals rarely include consideration of emissions from ICT, leaving a gap in both the academic and governing paradigms (Thiel et al., 2023).

1.2. Problem Statement

While telehealth has improved accessibility from a clinical and economic viewpoint, the environmental footprint is an increasing concern. The lack of integrated sustainability ideals threatens to sabotage the wider climate objectives laid down in the UN Sustainable Development Goals (SDGs) and also by the respective Net-Zero aspirations of the country's leading by example (Singh & Miller, 2023). Accordingly, there is an urgent need for a framework anterior to sustainability. A master plan that can evidence any conflicts between digital health innovation and environmental performance in the spheres of technology, operations and governance, is warranted.

1.3. Research Objectives

Research Aims This study aims to provide the Green Telehealth Framework (GTF) which comprises a conceptual model for sustainable digital healthcare. The aims of the research are:

1) Identify the environmental hotspots within some telehealth systems.

2) Put forward a sustainability framework integrating the cultural, operational and policy dimensions.

3) Validate this framework against real-world case studies.

4) Provide policy and cost-benefit analyses and discussions to facilitate implementation.

1.4. Research Questions

The study asks four important questions:

- What are the main environmental impacts of telehealth systems?
- How is sustainability embedded in the design of the ICTs and healthcare delivery?
- What policies and operational models facilitate and enable sustainable telemedicine scenarios?
- What are the quantifiable economic and environmental advantages of doing so?

1.5. Importance of the Study

The study addresses the global sustainability agenda by extending environmental responsibility into the digital health domain. The Green Telehealth Framework embodies the synergy of technological improvement, resource efficiency and governance systems, thus producing the potential strategic framework for low-carbon productivity in health services (United Nations, 2023). The alignment of SDG 3 (Good Health and Wellbeing), SDG 12 (Responsible Consumption and Production) and SDG 13 (Climate Action) enhances the role of health services in climate adaptation and planetary health (Eckelman & Sherman, 2016).

Structure of the Paper

The structure of the paper is as follows:

- **Chapter 2** reviews the literature in relation to sustainable health services and Green ICT and the associated policy frameworks associated with these areas.
- **Chapter 3** introduces the proposed Green Telehealth Framework (GTF).
- **Chapter 4:** reviews international case studies that illustrate the model in practice.
- **Chapter 5** examines the economic implications of cost-benefit analysis with associated policy recommendations.
- **Chapter 6** reviews the strategic implications and future research areas.
- **Chapter 7** summarizes the study with reviewed insights and findings.

2. Literature Review

2.1. Overview

Sustainability has long been a salient issue in health services, yet most environmental programs are centered on reduction of waste, building energy efficiency and transport logistics. The area of digital systems telehealth in particular are largely overlooked areas of health service contribution to the carbon footprint in health services. The global area of health services has a carbon footprint of 2 gigatons of CO_2 produced globally as part of this health sector per annum. Through digitalization there is an increase in proportion of carbon footprint by this sector. The energy intensity of telehealth is associated with storage of data, digital storage in cloud facilities, network bandwidth and the Internet of Medical Things (IoMT) devices, all of which are dependent in their operation on permanent energy use for aspects of operation and all need constant re–genesis of energy use and replacement of devices as well (World Health Organization, 2023).

This chapter examines existing research pertaining to four domains concerned with the GTF:

- Sustainability in health systems.
- Green ICT and energy-efficient infrastructure.
- Governance and policy mechanisms.
- Conceptual linkages between digital transformation and sustainability.

2.2. Sustainability in Health Systems

Initial sustainability efforts within health concentrated on resource efficiencies and control of facilities management issues (e.g., reducing waste, increasing energy efficiency of health systems); however, the advent of telehealth changed the agenda surrounding sustainability to a greater challenge in cyberspace. The World Health Organization Climate and Health Initiative calls attention to the fact that the transition to digital health must encompass ecological sustainability (Patel et al., 2023). Despite these observations, measures for assessing emissions from digital health systems remain uncoordinated or non-existent. For example, the present hospital carbon calculators don't include in their calculations teleconsultation energy requirements or the carbon lifecycle of the ICT systems used (Elkington, 1997).

2.3. Green ICT and Energy Efficiency in Telehealth

The ICT industry's environmental impact is comparable to aviation, consuming about 4% of global electricity (Ghisellini et al., 2016). Green ICT initiatives (e.g., server virtualization, data centers that are solar powered, bandwidth resource management initiatives) can make a considerable impact on reducing emissions from the digital elements of the health system. For example, Edge computing can significantly improve the energy efficiency of telehealth systems, reducing energy use by up to 30%, as critical data are processed in their near vicinity rather than sent to centralized points (Hartmann et al., 2022).

Similarly, circular utilization of devices emphasizing reuse of IoMT devices or recycling of the same is effective in reducing e-waste while improving device longevity (Montesinos et al., 2024). However, technical solutions are inadequate without the supporting operational and governance mechanisms to ensure the sustainability of the initiative.

2.4. Governance and Integration of Policy

The governance frameworks must play a determinative role in embedding sustainability into the digital health eco-systems. As a leading example of combining digital innovation with carbon accountability, the European Commission's Green Digital Transformation Strategy (European Commission, 2023) and Australia's Digital Health Sustainability Roadmap are employed (Australian Government, 2023).

Strong leadership is also demonstrated by the United Kingdom's National Health

Service (NHS), through its Net Zero Digital Health Strategy aimed at carbon disclosure, in ICT procurement and renewable-powered data center operations (NHS England, 2024). Governance thus becomes, the enabling resource to embed sustainability across whole health systems.

2.5. Conceptual and Analytical Foundations

The theoretical framework from which the GTF is derived is based upon the Triple Bottom Line (TBL) comprising economic, social and environmental performance (Elkington, 1997) and the Circular Economy (CE), turnover of resource renewal and life cycle optimization (Ghisellini et al., 2016). Although previous studies have proposed sustainability performance metrics within health, most remain descriptive. The GTF goes beyond fragmented models by putting sustainability into operation through technical, operational and policy metric measures.

2.6. Research Gaps Identified

This raised several unanswered issues:

- **Measurement gap:** No standardized metrics for digital health emissions.
- **Integration gap:** Insufficient coordination between ICT sustainability and operational health care.
- **Governance gap:** Fragmented accountability across institutions.
- **Economic gap:** A scarcity of cost-benefit models linking green innovation to financial performance.
- **Comparative gap:** Absence of cross-country evidence of sustainable telehealth.

This justifies the rationale for a conceptual framework that integrates environmental and operational objectives forming the basis for the Green Telehealth Framework proposed in Chapter 3.

In Figure 1, we show a conceptual timeline with a consideration of the conventional application of telemedicine for accessibility issues to the extension through the experimental and recognition of E-Health and the medical Internet of Things (information systems), through the sustainable features of digital health

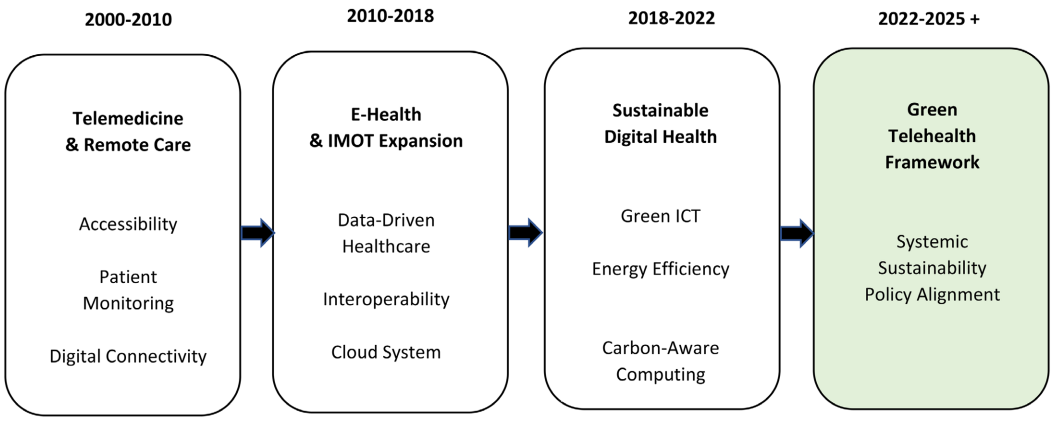

Figure 1. Progression of research areas in sustainable telehealth.

(Green ICT) and environmental awareness leads to the Green Telehealth Framework which includes an emphasis on the necessity for there to be a focus on sustainable features and policy compatibility.

3. Methods: Green Telehealth Framework

3.1. Overview

The literature review points out unmistakably that there is at present a discrete piecemeal approach undertaken by telehealth in regard to sustainability, particularly in so far as it relates to technology, operations and governance. There will be standalone Green ICT and policy projects in existence, but not one that addresses the three strands together in a coherent operational model (Patel et al., 2023).

This Chapter introduces the **Green Telehealth Framework (GTF)** which is a conceptual, holistic framework for the incorporation of sustainability in all aspects of the process of telehealth which places the environmental aspect as an integral building block to the health digitalization process and not as a definition, necessarily of things that will come later.

3.2. Conceptual Foundation

In addition to environmental and economic performance, the GTF pillars collectively advance social sustainability objectives such as health equity, accessibility, and patient trust.

The GTF is strongly influenced by systems theory, the Triple Bottom Line (TBL) (Elkington, 1997) and Circular Economy (CE) (Ghisellini et al., 2016) paradigm. These three elements are taken together holistically and structured as dependent pillars, in the following way:

- Efficiency/sustainable technology: the minimization of the carbon and ecofootprint of the telehealth structures.
- Operational sustainability: the incorporation of sustainable practices, efficiencies and routines.
- Policy conformity/governance: integration of the principles of sustainability importance into the processes of institutional governance regulations.

The interdependence of these three pillars represents the foundation of the Green Telehealth Framework (GTF) that is being recommended, as shown in more detail at **Figure 2**.

3.3. Pillar 1: Technological Efficiency

Technological efficiency is the prime pillar of the GTF. It refers to everything in relation to the techno-structure, management of the hardware life cycle, and optimal data transmission, etc.

The Core Components are:

- Renewable-powered data centers: shifting ICT operations to low-carbon grids (Hartmann et al., 2022).

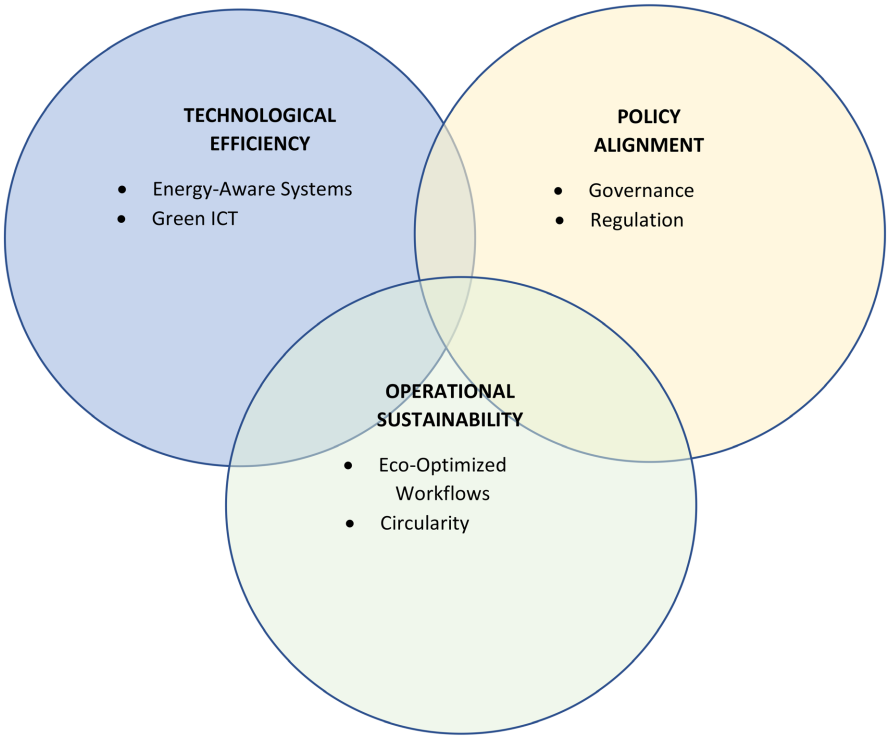

Figure 2. Green Telehealth Framework (GTF).

- Edge and hybrid cloud architectures: minimizing network latency and transmission energy.
- AI-driven resource scheduling: dynamically adjusting bandwidth and computation loads.
- Lifecycle management: ensuring IoMT devices are repairable, recyclable, and energy-rated (Montesinos et al., 2024).

The objective is to formulate a policy of maximum telehealth growth with no proportional growth in energy used.

3.4. Pillar 2: Operational Sustainability

The second pillar is operational sustainability which seeks to integrate the environmental aspects with operational actualities.

Important duties involve:

1) Workflow optimization: elimination of superfluous teleconsults that give rise to idle systems processing.

2) Sustainable procurement: the introduction of sustainability into vendor evaluation.

3) Carbon accounting: formation of Key Performance Indicators for emissions per telecall.

4) Workforce engagement and organizational culture: are fundamental to operational sustainability. Behavioral change, digital literacy, and environmental awareness among staff form the human infrastructure of sustainable telehealth. Embedding sustainability values within daily workflows ensures ecological responsibility

becomes routine, not peripheral (European Commission, 2023), e.g., scheduling, device handling, and virtual-clinic etiquette, making sustainability actionable across operations.

These processes can confirm the advantage of the successful migration of sustainability awareness from technology into normality and day-to-day operational health issues of telehealth process with regard to health.

3.5. Pillar 3: Policy Alignment and Governance

The third pillar is policy alignment and governance which is necessary for establishment of sustainability targets across the system and their scope to be somehow enlarged as necessary. Such policy initiatives may take the form of:

- Green ICT certification standards for software and infrastructure (NHS England, 2024).
- Mandatory sustainability reporting for health ICT vendors.
- Public procurement incentives favoring renewable and low-emission solutions.
- Inter-ministerial collaboration between health, ICT, and environmental bodies (Australian Digital Health Agency, 2024).

This policy-driven pillar ensures continuity and accountability in implementing sustainable telehealth systems.

3.6. Comparative Model Assessment

The uniqueness of the GTF framework lies in its ability to address all three elements of sustainability. A comparative outline of the distinct differences between the types of telehealth generally available and the Green Telehealth Framework is suggested in Table 1 which compares the standard telehealth options and approaches with the GTF option.

Table 1. Traditional telehealth systems and greener telehealth systems in comparison.

Dimension	Traditional Telehealth	Green Telehealth Framework
Energy Source	Conventional electricity	Renewable and hybrid energy grids
Network Design	Centralized data flow	Edge-enabled distributed processing
Device Lifecycle	Linear (use-discard)	Circular (reuse-recycle)
Operational Focus	Throughput and cost	Efficiency and sustainability
Governance	Voluntary compliance	Regulatory enforcement
Measurement	Limited to service quality	Includes energy and emission KPIs

3.7. Implementation Strategy

Implementing the GTF requires a phased transition adaptable to institutional capacity:

1) Assessment: baseline audit of ICT energy and emissions.

2) Planning: target setting aligned with Net-Zero objectives.

3) Integration: embedding metrics into telehealth strategy and procurement.

4) Monitoring: tracking sustainability indicators.

5) Improvement: iterative adjustments via feedback loops (United Arab Emirates Ministry of Health and Prevention [MOHAP], 2024).

3.8. Anticipated Benefits

- Environmental: Reduced energy intensity and e-waste.
- Economic: Long-term cost savings through resource optimization.
- Social: Enhanced patient trust in eco-responsible healthcare.
- Policy: Strengthened alignment with national climate commitments.

3.9. Summary

The Green Telehealth Framework is an integrated basis for making digital healthcare sustainable. It is only by bringing together technological innovation, etc. It provides the basis for climate readiness and action in health care transformation.

In Chapter 4 we will investigate how the framework might apply through 3 sets of real-life case studies.

4. Results: Comparative Case Studies

4.1. Overview

In order to validate the GTF it is proposed to set forward 3 sets of national case studies:

- The United Kingdom (NHS Net Zero Digital Health)
- Australia (ADHA Digital Health Sustainability Roadmap)
- United Arab Emirates (UAE Smart Health Vision 2031)

These countries were selected to represent distinct pathways toward sustainable telehealth. The United Kingdom exemplifies a regulation-driven model emphasizing carbon accountability; Australia represents a technology-led innovation route focusing on edge computing and rural equity; and the United Arab Emirates demonstrates an emerging-economy model integrating renewable energy and digital transformation. All three represent different routes to sustainable telehealth implementation that are compliant with GTF pillars (Henderson et al., 2013).

4.2. Global Context

Worldwide, over 70% of countries' national strategies now include digital health but fewer than 25% include measurable sustainability metrics. This discrepancy represents the need for structured governance models, such as GTF (U.S. Department of Health and Human Services, 2024). All countries in **Figure 3** show the global incidence of telehealth initiatives of sustainability, highlighting those countries that have thus far instituted national digital health strategies that are qualified on the dimensions of environmental performance.

Figure 3. Illustration of green telehealth initiatives for our 3 case study countries.

World map showing 3 countries of our Case Study that have instituted sustainability-related telehealth policies and programs. In particular, observable is the NHS England Net Zero Digital Health Strategy (NHS England, 2024), Australia's Digital Health Sustainability Roadmap (Australian Government, 2024) and the UAE Smart Health Vision 2031 (United Arab Emirates Ministry of Health and Prevention, 2024).

4.3. Case Study 1: United Kingdom (NHS)

Overview

The United Kingdom's NHS launched the Net Zero Digital Health Strategy in 2020, mandating environmental accountability across ICT operations (NHS England, 2024).

Key Sustainability Measures

- Migration to renewable-powered cloud infrastructure.
- Implementation of AI-based teleconsultation scheduling.
- Supplier carbon disclosure requirements.

Outcomes

By 2024, NHS England reported a 26% reduction in ICT energy use and USD 32 million annual cost savings (NHS England, 2024).

4.4. Case Study 2: Australia (ADHA)

Overview

The Australian Digital Health Agency (ADHA) embeds sustainability into its *Digital Health Sustainability Roadmap*, focusing on rural equity and energy efficiency.

Measures

- Edge computing for regional telehealth hubs.
- Lifecycle-based ICT procurement.

- Partnerships with telecoms for low-power 5G deployment.

Outcomes

ADHA achieved a 33% energy reduction and USD 11 million annual savings between 2022 and 2024 (Australian Digital Health Agency, 2024).

4.5. Case Study 3: United Arab Emirates (MOHAP)

Overview

The UAE's *Smart Health Vision 2031* integrates sustainability through solar-driven telehealth and AI-optimized hospital ICT (United Arab Emirates Ministry of Health and Prevention, 2024).

Measures

- Solar-powered mobile health units.
- AI-based power management in hospitals.
- Nationwide e-prescription rollout.

Outcomes

From 2020 to 2024, MOHAP reported a 22% reduction in power consumption and a 45% decrease in paper-based workflows, enhancing efficiency and reducing waste (Thiel et al., 2023).

4.6. Comparative Insights

All three national implementations of the Green Telehealth Framework (GTF) show that the integration of sustainability means different processes. Each system implements major changes, though through consortium-based governance structures, public sector maturity of systems and variations in aims set through the political process. As shown in **Figure 4**, all three cases showed measurable environmental improvements in measured results, financial savings and improvements capable through the evolution towards a GTFs compliant structure. The NHS in the United Kingdom has already met with a 26% reduction in energy and CO_2 emissions related to the ICT environment and an effectiveness yearly improvement of approximately USD 32 million through the use of renewable-powered data centers. Australia, in the development of ADHA showed that a 33% reduction in the use of energy was translated into a yearly saving to the taxpayer of USD 11 million through the deployment of regional edge hubs based on the GTF integration model, through a process of circular procurement. The MOHAP department of the United Arab Emirates saw, since the framework was adopted, in a country with a prevailing high outdoor temperature climate almost year-round, a reduction in energy of 22% and, in paper consumption, 45% through solar-powered units of Telehealth and full digitization of Clinical workflow processes in hospitals.

These core improvement results verifying the GTF pillars of technological efficiency, operational sustainability and the required general policy adjustment recommend transferability of the GTF compliance basis relevant across a diversity of national integrative environments.

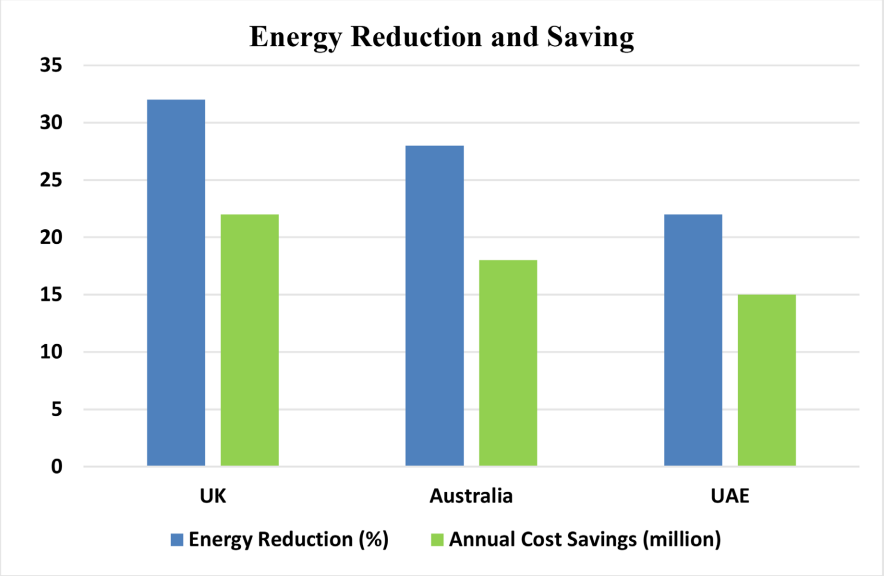

Figure 4. Comparative telehealth sustainability outcomes.

4.6.1. Comparative Discussion

Explicit validation of GTF pillars: Australia's success with edge computing directly validates the Technological Efficiency pillar; the United Kingdom's supplier carbon-disclosure mandates directly validate the Policy Alignment pillar; and the United Arab Emirates' solar-powered telehealth and paperless workflows validate the Operational Sustainability pillar.

1) Energy Performance:

Among the three, Australia demonstrated the highest relative energy efficiency gains, largely due to its decentralized edge-based infrastructure that minimized data-transmission loads.

2) Cost-Benefit Alignment:

The correlation between cost savings and energy reduction suggests that environmental performance directly enhances economic efficiency supporting the proposition that "sustainability pays back".

3) Policy Integration:

The United Kingdom's outcome highlights how stringent regulatory frameworks can accelerate emission reductions even in legacy ICT environments. The UAE's top-down innovation model further illustrates how emerging economies can leapfrog toward sustainability by investing in renewable energy from the outset.

4) Scalability and Transferability:

Despite differences in governance maturity and infrastructure, each country succeeded by adapting the GTF pillars to local constraints. This adaptability underscores the framework's global relevance for both developed and developing healthcare systems.

5) Cross-Pillar Synergy:

The strongest results emerged where all three pillars operated synergistically—

technology optimization supported by operational reform and sustained through governance oversight.

Table 2 presents a comparative synthesis of findings from the three national case studies, United Kingdom, Australia, and the United Arab Emirates, mapped against the three pillars of the Green Telehealth Framework (GTF): *Technological Efficiency*, *Operational Sustainability*, and *Policy Alignment*.

The analysis highlights how each country demonstrates distinct yet complementary approaches:

- The **United Kingdom** emphasizes *policy-driven decarbonization* through supplier carbon-disclosure mandates and renewable-energy-based data centers.
- **Australia** showcases *technology-led efficiency* via edge-computing infrastructure and distributed telehealth hubs that lower transmission energy use.
- The **United Arab Emirates** integrates *operational sustainability* through solar-powered mobile units, paperless workflows, and green digital transformation initiatives.

Together, these insights validate the adaptability of the GTF model across diverse regulatory, technological, and infrastructural contexts.

Table 2. Summary of comparative insights.

Country	Key Strengths	Challenges	Primary GTF Emphasis	Overall Impact
United Kingdom	Regulatory enforcement, funding consistency	Legacy ICT infrastructure	Policy Alignment	High, stable gains
Australia	Edge-based innovation, data efficiency	Hardware upgrade costs	Technological Efficiency	Maximum energy savings
UAE	Renewable energy integration, agile policy	Data standardization gaps	Balanced across pillars	Strong environmental benefits

4.6.2. Analytic Conclusions

In all three instances, sustainability and cost effectiveness were positively correlated, verifying the central hypothesis of the Green Telehealth Framework: that technological modernization is most effective when directed by principles of sustainability, which are shown in both operational performance and distributional ecological responsibility.

These comparative insights set the stage for Chapter 5, which further quantifies cost–benefit outcomes and explores the policy mechanisms enabling scalable implementation.

4.7. Summary

The three case studies verify that the Green Telehealth framework is both effectively experienced and potentially scalable to various regimes of governance and

infrastructure metrics. All realized identifiable environmental and financial returns while upholding quality of service affording the GTF a universally transferable model of sustainability in the digital field of healthcare.

5. Results: Cost-Benefit and Policy Implications

5.1. Overview

While sustainability in telehealth is largely regarded as a moral or regulatory requirement, the evidence increasingly reflects that there are also readily identifiable quantifiable financial and strategic benefits, with the introduction of green ICT infrastructures and circular procurement models leading to considerable savings while appreciably improving resilience (Dymyt & Wincewicz-Bosy, 2024).

This chapter will consider the economic, environmental and policy implications of the implementation of the Green Telehealth Framework (GTF) with comparative evidence sourced from the United Kingdom, Australia and the United Arab Emirates.

5.2. Economic Performance and Efficiency

5.2.1. Direct Financial Benefits

The three case studies covered show that electricity optimized digital infrastructures allow a savings of 25% - 35% in electricity costs over three years of operation (Li et al., 2025).

The lifecycle management of the IoMT devices' refurbishment and reuse allows additional savings of 15% - 20% in procurement costs (Rancea et al., 2024).

Additionally, the hybridization of cloud to edge infrastructures leads to low levels of data transmission costs and optimal efficient use of data bandwidth that saves an additional 10%-15% of total operational costs (Zhai et al., 2024).

5.2.2. Indirect and Strategic Benefits

- Lowered administrative costs with paperless workflows through automated scheduling.
- Obtaining eligibility for sustainability grants and scoring of preferential public procurement contracts.
- Enhanced institutional reputation, leading to new partnership opportunities and improved stakeholder trust.

Collectively, the manifestation of all these benefits shows that quantifiable returns on environmental sustainability and financial prudence are mutually reinforcing rather than exclusive competing.

5.3. Mitigation of Environmental Impact

Implementing sustainable telehealth solutions can lead to an overall reduction of between 40% and 70%, in ICT's total emissions (compared with conventional healthcare solutions provided in-house), particularly if these telehealth implementations are powered by renewable energy (Patel et al., 2023).

A comparative summary of annual cost savings, energy savings and avoided CO_2 emissions from three national implementations of the Green Telehealth Framework (GTF).

Table 3. Comparative benefits of cost and emission.

Country	Annual Cost Savings	Energy Reduction	CO_2 Reduction	Primary Enabler
UK (NHS)	USD 32 million	26%	18 kt/year	Renewable-powered cloud
Australia (ADHA)	USD 11 million	33%	22 kt/year	Edge telehealth networks
UAE (MOHAP)	USD 12 million	22%	15 kt/year	Solar-powered systems

The information presented in Table 3 indicates that by employing sustainability techniques this not only results in energy performance gains being achieved but also benefits from a costing perspective that are seen as permanent, as indicated by the established correlations between costing benefits as summarized here.

5.4. Social/Ethical Outcomes

Beyond measurable financial and environmental results, Green Telehealth delivers social and ethical dividends:

1) Equitable Access: Lower costs facilitate expansion into underserved regions.

2) Workforce Productivity: Streamlined workflows and data efficiency reduce clinician fatigue.

3) Public Trust: Transparent sustainability reporting enhances patient confidence and system credibility (Mennella et al., 2024).

In this sense, Green Telehealth strengthens both the ethical and operational pillars of healthcare sustainability.

5.5. Policy Implications

5.5.1. Policy Frameworks for Implementation

The long-term, system-wide economic and environmental benefits from Green Telehealth can be realized through solid policy framing. The Green Telehealth Framework (GTF) indicates that these cost-benefit successes can only be achieved if the necessary political frameworks exist to ensure that the economic incentives operate hand-in-hand with the sustainability obligations. The following are the political tools, identified in Table 4, that are critical enablers towards the full scaling of sustainable telehealth practices at a global level.

5.5.2. Integrating Policy with Cost-Benefit Outcomes

The financial breakeven for sustainable telehealth typically occurs within 2.5

Table 4. Political/funding instruments supporting the green telehealth initiation.

Policy Instrument	Primary Objective	Implementation Mechanism	Example of Application
Green ICT Certification	Establish quality and sustainability benchmarks for telehealth platforms and data centers.	Certification systems managed by health or ICT regulatory agencies.	EU *Green Cloud Label* certifies low-emission cloud infrastructure.
Carbon Reporting Mandates	Promote transparency in ICT emissions and energy consumption.	Annual carbon disclosure required for public-sector digital health suppliers.	UK *NHS Supplier Standards* mandate ICT carbon audits.
Incentive Programs	Encourage healthcare providers to adopt renewable and energy-efficient infrastructure.	Government subsidies, tax reductions, or innovation grants for compliant systems.	*Australia CleanTech Health Fund* supports low-energy health technologies.
Public Procurement Standards	Embed sustainability KPIs in tender criteria to prioritize eco-compliant vendors.	Weighted scoring systems for lifecycle energy and emission performance.	UAE *Digital Health Procurement Rules* require sustainability documentation.
Cross-Ministerial Coordination	Align healthcare, ICT, and environmental ministries under unified sustainability goals.	Formal inter-agency committees and integrated reporting dashboards.	OECD *Whole-of-Government Approach* to sustainable digital transformation.

years. For policies which are targeted towards reducing the initial capital barrier to entry or facilitating the narrowing of the time-frame possible for the take-up of this telehealth sustainability process to be achieved, i.e., tax concessions, grants, loan subsidies, there exist possibilities for further narrowing of the time which it takes to reach the breakeven point allowing returns to have net positive yield much more rapidly.

For example:

- Green ICT certification and carbon reporting help standardize performance metrics, ensuring consistent monitoring of Return On Investment (ROI) across institutions.
- Procurement standards institutionalize sustainability, allowing large-scale health systems (e.g., NHS, ADHA) to negotiate cost savings through consolidated eco-friendly vendor contracts.
- Cross-ministerial coordination eliminates bureaucratic duplication, streamlining policy execution and improving the long-term efficiency of sustainable health infrastructure.

These instruments collectively transform sustainability from a voluntary effort into a structured economic strategy, ensuring that environmental responsibility is tied directly to financial viability.

5.5.3. Policy Economics Alignment

Reinforcement of linking the policy tools with the economic benefits has been developed fully, reinforcing the main argument in this paper:

"Sustainability in telehealth is self-reinforcing once the right policy environment is in place; financial and environmental gains compound over time."

Thus, Table 3 and Table 4 present a dual narrative: policy intervention accelerates economic payoff, while economic efficiency validates policy sustainability goals.

5.5.4. Barriers to Implementation

Key challenges remain:

- **High initial investment costs** for renewable infrastructure.
- **Data standardization gaps** across ICT vendors.
- **Limited sustainability expertise** within hospital administration.
- **Policy fragmentation** between ministries.

Addressing these requires intersectoral collaboration and consistent regulatory oversight.

5.6. Cost Benefit Dynamics

A long-term return on investment for green telehealth will follow a delayed benefit curve where initial infrastructure costs will be balanced by cumulative savings within 2 to 3 years.

The relationship between sustainability investment and cumulative benefit over time is shown in Figure 5 which shows the point where operational savings become

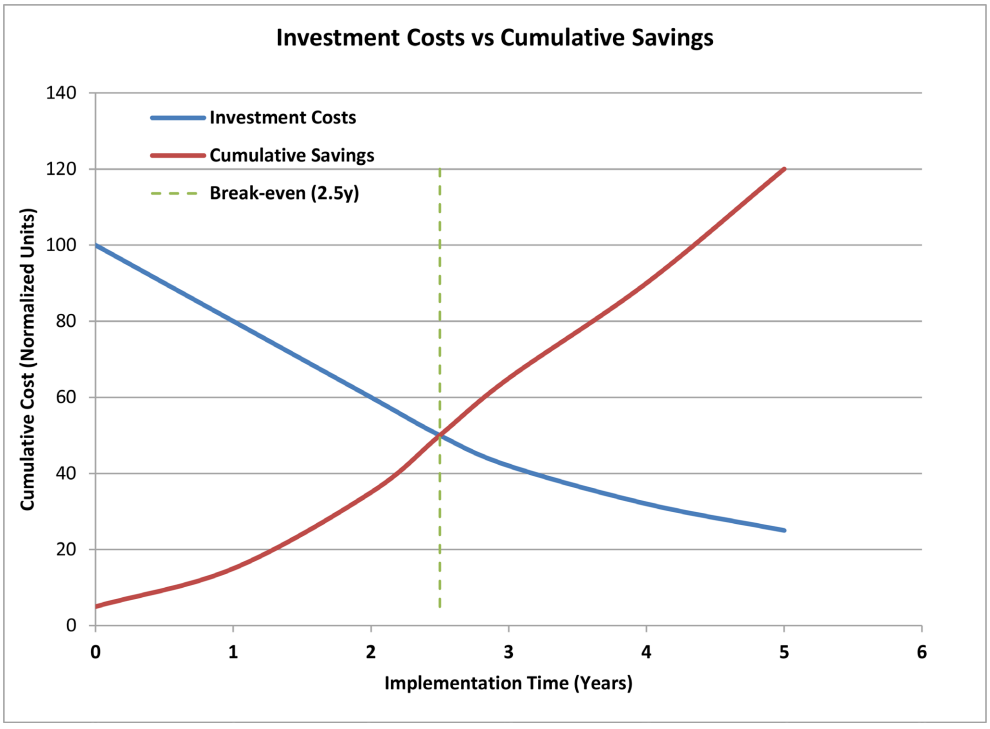

Figure 5. Cost-benefit crossover in sustainable telehealth.

greater than the initial infrastructure costs.

A conceptual line graph shows how initial sustainability investment expenses (initial cost curve) relate to complete operational and environmental cost reductions (savings curve) during five years. The intersection reaches the breakeven point during years 2 to 3 when green telehealth becomes profitable and starts generating positive results in terms of cost savings and energy efficiency.

The research demonstrates that sustainability generates financial advantages for organizations that extend their planning horizon to a medium-term perspective.

5.7. Strategic Policy Alignment

The embedding of the Green Telehealth Framework in national digital health strategies ensures that there is synergy with larger sustainability frameworks such as the Paris Agreement, UN SDGs and Net-Zero 2050 targets. Public-private partnerships help speed up the adoption of the green telehealth model through combined efforts to develop new technologies and share infrastructure costs.

5.8. Summary

The Green Telehealth Framework shows environmental value through policy assessment and demonstrates both financial stability and political workability. Telehealth can serve as a model for health sector innovation through policy instruments that create sustainability frameworks and function as tools to carry out climate change actions.

The successful deployment of sustainable telehealth systems needs appropriate policy instruments to carry out their implementation. The measures decrease investment risks while making investors more responsible and encouraging new solutions that help reach Net-Zero targets. The strategic use of these instruments results in shorter breakeven periods which generate enduring value for healthcare organizations and economic and environmental sectors.

6. Discussion

The findings from case studies and cost analysis confirm that the Green Telehealth Framework offers an effective blueprint for aligning healthcare digitalization with sustainability imperatives. It establishes a synergistic relationship between technological modernization, resource efficiency, and environmental governance (OECD, 2019).

This chapter interprets these findings, explores practical and theoretical implications, and identifies future research priorities.

6.1. Convergence of Digitalization and Sustainability

Historically, digital transformation and sustainability were treated as separate domains—one focused on efficiency, the other on ethics. The GTF demonstrates that these can be unified into a single operational paradigm, where every digital advancement contributes to environmental goals (Rancea et al., 2024).

Energy-aware computing, low-carbon networks, and eco-designed devices prove that environmental and economic performance can converge under properly aligned policy and technology ecosystems.

6.2. Practical Implications

6.2.1. For Healthcare Organizations

Hospitals and telehealth agencies can adopt the GTF as a strategic tool for assessing sustainability readiness. Embedding carbon tracking and energy KPIs within digital performance dashboards promotes transparency and accountability.

6.2.2. For Policymakers

Governments can reinforce GTF adoption through mandatory sustainability reporting, green ICT incentives, and renewable procurement policies.

Such measures align healthcare objectives with national environmental strategies (Singh & Rodriguez, 2023).

6.2.3. For Technology Developers

Manufacturers and software vendors can design low-power AI algorithms, modular hardware, and biodegradable medical sensors, contributing to lifecycle sustainability and compliance readiness (Pereno et al., 2015).

6.3. Theoretical Contributions

The GTF contributes to academic discourse in four ways:

1) Integrates Green ICT, Circular Economy, and Governance theory into a unified framework.

2) Provides measurable performance indicators linking environmental and clinical outcomes.

3) Demonstrates cross-sector scalability through international case validation.

4) Establishes sustainability as a theoretical extension of telehealth quality.

6.4. Limitations

Despite its strengths, several limitations exist:

- Reliance on secondary data limits empirical depth.
- Carbon accounting methods remain inconsistent across systems (Rancea et al., 2024).
- Rapid technological evolution may require ongoing framework updates.
- Policy adoption varies significantly between high- and low-income countries.

6.6. Future Research Directions

The next phase of research should:

1) Develop standardized carbon metrics for telehealth.

2) Explore AI-based predictive sustainability models.

3) Study behavioral influences on digital energy use among clinicians and patients.

4) Test GTF implementation in resource-limited regions.

5) Create open-source tools for lifecycle impact assessments.

These studies will help refine GTF's robustness and global adaptability.

6.7. Strategic Outlook

The future of telehealth lies in sustainable digital ecosystems.

By integrating environmental KPIs into healthcare governance, sustainability becomes a core performance criterion. Emerging technologies including AI, 5G, and renewable edge computing will accelerate this transition.

Over the next decade, sustainability will evolve from an optional feature to a core accreditation requirement in global telemedicine standards.

6.8. Summary

The Green Telehealth Framework bridges a critical gap in global healthcare transformation: how to digitize without damaging the environment.

By linking sustainability to technology and policy, it ensures that healthcare's digital revolution advances hand-in-hand with planetary well-being.

7. Conclusion

7.1. Summary of the Study

The Green Telehealth Framework (GTF) provides a sustainable telehealth solution that addresses digital health delivery sustainability problems while enhancing operational efficiency and financial stability. The study found that sustainability of telehealth systems is a practical task founded not only on sustainability theory, digital transformation concepts, and evidence gained from three national implementation studies (United Kingdom, Australia, United Arab Emirates), but a contributing advantage as well (Capodici et al., 2025).

The GTF combines features of technological efficiency, operational sustainability and policy engagement within a cohesive framework of health care systems to allow carbon responsible innovation. The GTF structure validates its effectiveness through real-world evidence which demonstrates its readiness for worldwide deployment and operational readiness.

7.2. Key Findings

1) Sustainability and Efficiency Converge:

Green ICT solutions such as renewable data centers and edge computing reduce energy consumption by up to 30% while improving performance (Zhai et al., 2024).

2) Policy Integration Accelerates Progress:

Mandated sustainability reporting and procurement incentives drive faster adoption and measurable results.

3) Economic Feasibility:

The cost-benefit analyses revealed operational savings of 20% - 30% after two years, proving that sustainability is financially viable.

4) Behavioral and Cultural Shifts Matter:

As detailed in Section 3.4 (Operational Sustainability), user behavior and organizational culture are critical enablers of sustainable telehealth. Future research should focus on measurement and standardized behavioral KPIs, rather than establishing their primary role.

5) Global Relevance:

The framework is adaptable to varying resource levels, providing a scalable foundation for global health systems seeking Net-Zero transformation.

7.3. Theoretical and Practical Contributions

The Green Telehealth Framework advances knowledge by:

- Integrating environmental sustainability into the theoretical foundation of digital health management.
- Introducing measurable metrics that link healthcare performance to ecological outcomes.
- Demonstrating through case evidence that policy alignment and technological innovation can produce complementary benefits.
- Establishing sustainability as a new dimension of healthcare quality alongside accessibility, safety, and effectiveness (World Health Organization, 2024).

7.4. Limitations

While comprehensive, the research relied primarily on documented national reports rather than primary energy audits.

Future studies should incorporate quantitative carbon-accounting methodologies and cross-institutional datasets to strengthen empirical validation. Additionally, rapid advances in AI, 6G, and IoMT devices will require periodic refinement of sustainability metrics.

7.5. Future Outlook

As healthcare increasingly digitizes, the ecological implications of telehealth will shape policy and design choices worldwide.

The next decade will see sustainability indicators become mandatory in accreditation, funding, and reporting frameworks. Emerging innovations including AI-driven carbon management, biodegradable sensors, and renewable-powered edge systems will anchor the future of eco-smart healthcare (Australian Government, 2024).

In this context, the GTF offers a living framework that is adaptable to new technologies and governance models, ensuring that healthcare's digital revolution contributes positively to planetary well-being.

7.6. Concluding Statement

The Green Telehealth Framework demonstrates that sustainability and digital innovation are not competing priorities but mutually reinforcing imperatives.

By embedding environmental accountability within healthcare technology, operations, and governance, telehealth can evolve into a cornerstone of climate-resilient healthcare.

In essence, the future of healthcare must be both digital and sustainable and Green Telehealth provides the roadmap to get there.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

Australian Digital Health Agency (ADHA) (2024). *Australian Digital Health Agency Annual Report 2023-2024*. Australian Government. https://www.digitalhealth.gov.au/

Australian Government, Department of Finance (2023). *Net Zero in Government Operations Strategy*. https://www.finance.gov.au/publications/net-zero-strategy

Australian Government, Department of Health (2024). *National Health and Climate Strategy 2024 Implementation Progress Report*.

Montesinos, L., Checa Rifá, P., Rifá Fabregat, M., Maldonado-Romo, J., Capacci, S., Maccaro, A. et al. (2024). Sustainability across the Medical Device Lifecycle: A Scoping Review. *Sustainability, 16,* Article 1433. https://doi.org/10.3390/su16041433

Capodici, A., Noci, F., Nuti, S., Emdin, M., Dalmiani, S., Passino, C. et al. (2025). Reducing Outpatient Wait Times through Telemedicine: A Systematic Review and Quantitative Analysis. *BMJ Open, 15,* e088153. https://doi.org/10.1136/bmjopen-2024-088153

Mennella, C., Maniscalco, U., De Pietro, G., & Esposito, M. (2024). Ethical and Regulatory Challenges of AI Technologies in Healthcare: A Narrative Review. *Heliyon, 10,* e26297. https://doi.org/10.1016/j.heliyon.2024.e26297

Eckelman, M. J., & Sherman, J. (2016). Environmental Impacts of the U.S. Health Care System and Effects on Public Health. *PLOS ONE, 11,* e0157014. https://doi.org/10.1371/journal.pone.0157014

Elkington, J. (1997). *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*. Capstone Publishing.

European Commission (2023). *Green and Digital Transition in Healthcare: EU Progress Report*. https://health.ec.europa.eu/

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems. *Journal of Cleaner Production, 114,* 11-32. https://doi.org/10.1016/j.jclepro.2015.09.007

Henderson, C., Knapp, M., Fernandez, J., Beecham, J., Hirani, S. P., Cartwright, M. et al. (2013). Cost Effectiveness of Telehealth for Patients with Long Term Conditions (Whole Systems Demonstrator Telehealth Questionnaire Study): Nested Economic Evaluation in a Pragmatic, Cluster Randomised Controlled Trial. *BMJ, 346,* f1035. https://doi.org/10.1136/bmj.f1035

International Energy Agency (IEA) (2024). *Electricity—Mid-Year Update 2024*.

Pereno, A., Barbero, S., & Tamborrini, P. (2015). Design for Healthcare Sustainability: Ethical Implications of Eco-Design Research. *In The Value of Design Research—Proceedings of the 11th International Conference of European Academy of Design Conference* (pp. 1-15).

Li, H. et al. (2025). Economic Evaluations and Financial Consequences Related to the Use

of Telehealth for Older Adults: A Systematic Review. *BMC Digital Health, 2,* Article No. 99.

Hartmann, M., Hashmi, U. S., & Imran, A. (2022). Edge Computing in Smart Health Care Systems: Review, Challenges, and Research Directions. *Transactions on Emerging Telecommunications Technologies, 33,* e3710. https://doi.org/10.1002/ett.3710

NHS England (2024). *Delivering a Net Zero National Health Service: 2024 Progress Report*. NHS England Publications. https://www.england.nhs.uk/greenernhs

Organisation for Economic Co-Operation and Development (OECD) (2019). *Health in the 21st Century: Putting Data to Work for Stronger Health Systems*. OECD Publishing. https://doi.org/10.1787/e3b23f8e-en

Patel, K. B., Gonzalez, B. D., Turner, K., Alishahi Tabriz, A., Rollison, D. E., Robinson, E. et al. (2023). Estimated Carbon Emissions Savings with Shifts from In-Person Visits to Telemedicine for Patients with Cancer. *JAMA Network Open, 6,* e2253788. https://doi.org/10.1001/jamanetworkopen.2022.53788

Rancea, A., Anghel, I., & Cioara, T. (2024). Edge Computing in Healthcare: Innovations, Opportunities, and Challenges. *Future Internet, 16,* Article No. 329. https://doi.org/10.3390/fi16090329

Singh, A., & Rodriguez, M. (2023). Digital Governance and Environmental Alignment in Health Systems. *Government Information Quarterly, 40,* Article ID: 101868.

Singh, K., & Miller, T. (2023). Sustainability Integration in National Telehealth Strategies: A Policy Analysis. *Health Policy and Technology, 12,* Article ID: 100728.

Dymyt, M., & Wincewicz-Bosy, M. (2024). A Concept of a Sustainable Digital Healthcare System. *In Adoption of Emerging Information and Communication Technology for Sustainability* (pp. 87-104). CRC Press. https://doi.org/10.1201/9781003316572-6

Thiel, C. L., Mehta, N., Sejo, C. S., Qureshi, L., Moyer, M., Valentino, V. et al. (2023). Telemedicine and the Environment: Life Cycle Environmental Emissions from In-Person and Virtual Clinic Visits. *NPJ Digital Medicine, 6,* Article No. 87. https://doi.org/10.1038/s41746-023-00818-7

U.S. Department of Health and Human Services (HHS) (2024). *Telehealth Research Recap: Economic Impact*. https://telehealth.hhs.gov/documents/ResearchRecap-Telehealth_and_Economic_Impact_09-30-24.pdf

United Arab Emirates Ministry of Health and Prevention (MOHAP) (2024). *Smart Health Vision 2031 Policy Paper*. https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/innovation-and-future-shaping/we-the-uae-2031-vision

United Nations (2023). *Sustainable Development Goals Report 2023*. UN Publications. https://unstats.un.org/sdgs/report/2023/The-Sustainable-Development-Goals-Report-2023.pdf

Zhai, X., Peng, Y., & Guo, X. (2024). Edge-Cloud Collaboration for Low-Latency, Low-Carbon, and Cost-Efficient Operations. *Computers and Electrical Engineering, 120,* Article 109758. *https://doi.org/10.1016/j.compeleceng.2024.109758*

World Health Organization (WHO) (2021). *Operational Framework for Building Climate-resilient Health Systems*. https://apps.who.int/iris/handle/10665/350147

World Health Organization (WHO) (2023). *Global Report on Health and Climate Change: 2023 Update*.

World Health Organization (WHO) (2024). *Telehealth and Climate Action: Leveraging Digital Transformation for Sustainable Health*.

Appendix A: Abbreviations

Abbreviation	Full Form
ADHA	Australian Digital Health Agency
AI	Artificial Intelligence
CE	Circular Economy
CO_2	Carbon Dioxide
GTF	Green Telehealth Framework
ICT	Information and Communication Technology
IEA	International Energy Agency
IoMT	Internet of Medical Things
KPI	Key Performance Indicator
MOHAP	Ministry of Health and Prevention (UAE)
NHS	National Health Service (United Kingdom)
OECD	Organisation for Economic Co-operation and Development
SDG	Sustainable Development Goal