

Leveraging Information Technology for Sustainability in Healthcare with Telemedicine

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Abstract

The integration of information technology, notably through telemedicine, is undergoing profound transformations within the healthcare sector. This research delves into the interplay between information technology and sustainability in the healthcare industry, with a specific focus on the impact of telemedicine. It explores the multifaceted dimensions of this integration, encompassing social, economic, and environmental aspects. Emphasizing the potential ramifications, the study highlights how leveraging information technology can enhance healthcare accessibility and quality while concurrently reducing carbon emissions. By examining the broader implications of this technological integration, including its societal, financial, and ecological dimensions, the research aims to shed light on the transformative potential of information technology in fostering a more sustainable and equitable healthcare system. Through comprehensive analysis, it seeks to provide insights into the evolving landscape of healthcare delivery and the pivotal role played by telemedicine in shaping a more resilient and environmentally conscious healthcare industry.

Keywords: Telemedicine, healthcare, sustainability, Information technology, carbon footprint, environmental impact, green technology, emission, IoT, AI, waste

INTRODUCTION

Background

The healthcare industry has recently been under increasing pressure to manage its environmental impact as knowledge of climate change and ecological issues has grown. Traditional healthcare practices' carbon footprint, which includes energy intensive facilities, transportation emissions, and medical waste, has become a source of concern for the environment. As a result, integrating information technology, particularly telemedicine, has emerged as a disruptive option. Telemedicine has the potential to transform healthcare delivery while drastically decreasing the sector's environmental footprint, thanks to its digital platforms and remote communication technology [1]. This transition corresponds with global environmental goals, but also solves the difficulties of healthcare accessibility and quality.

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Definition

Telemedicine involves using information and communication technologies (ICTs) to deliver healthcare services when there is a physical distance between care providers and recipients (Figure 1). It emphasizes the transmission of voice, data, images, and information over physically relocating patients, healthcare professionals, or educators. Telemedicine encompasses both preventive and curative aspects of healthcare and includes remote clinical services such as diagnosis, monitoring, advice, education, and intervention. Examples are video conferences between clinicians and patients

		Information Transmitted	
Interaction		Still images	Moving image (video)
	Real-time		e.g. telepsychiatry
	Pre-recorded	e.g. teleradiology	

Figure 1. Classification system for telemedicine episodes.

to remote monitoring of health data and robotic surgery. This method not only conserves time and expenses related to travel but also ensures immediate medical assistance, particularly during urgent situations [2].

OBJECTIVES

This study aims to delve deeply into the following key areas:

Reducing Carbon Footprints

Investigate the ways in which telemedicine significantly diminishes the carbon footprint of healthcare services. This includes analyzing the reduction in energy consumption, transportation related emissions, and the overall environmental impact of digital healthcare practices.

Enhancing Healthcare Accessibility

Examine how telemedicine improves healthcare accessibility, particularly in underserved and remote regions. Investigate the role of technology in bridging the healthcare gap and ensuring that quality medical services are accessible to diverse populations, irrespective of geographical constraints.

Ensuring Long-term Sustainability

Evaluate the long-term sustainability of telemedicine solutions. This involves studying the scalability, adaptability, and eco-efficiency of telemedicine platforms over time. Additionally, the research will explore the policies, strategies, and innovations necessary to ensure the enduring environmental sustainability of telehealth practices [3].

TRADITIONAL HEALTHCARE PRACTICES AND ENVIRONMENTAL IMPACT

Detailed insights into the environmental impact of traditional healthcare practices, emphasizing the interconnectedness of energy consumption, waste generation, and environmental degradation are given as follows:

Carbon Emissions

Energy Consumption

Healthcare facilities consume a large amount of energy to operate. This energy serves various purposes such as illuminating spaces, regulating temperature, powering medical devices, and managing electronic data. In the United States, roughly 10% of the overall energy consumption is attributed to the healthcare sector [4].

Waste Generation

Healthcare facilities also generate a significant amount of waste. This waste includes medical waste, such as used needles, syringes, and bandages, as well as general waste, such as food scraps, paper, and plastic. In the United States, the healthcare sector generates an estimated 5.9 million tons of waste per year.

Transportation Related Emissions

Transportation-related emissions are another significant contributor to the environmental impact of traditional healthcare practices. Patients and staff travel to and from healthcare facilities in cars, buses, and other vehicles. This travel generates greenhouse gas emissions and other pollutants [5].

Medical Waste Management

Medical waste management presents numerous hurdles. Among these challenges is the safe disposal of hazardous materials, which necessitates specialized facilities to avert environmental harm. Another obstacle involves the proper sorting of medical waste to mitigate the risk of infection transmission. Furthermore, many countries lack uniform guidelines for managing medical waste, resulting in potential mishandling and subsequent environmental hazards, such as [6]:

- *Soil and water contamination:* Medical waste can contaminate soil and water bodies, posing a risk to human health and the environment.
- *Air pollution:* Incineration of medical waste can release harmful pollutants into the air, including dioxins, furans, and heavy metals.
- *Spread of disease:* Improperly disposed of medical waste can spread infectious diseases, such as HIV, hepatitis, and tuberculosis.

Energy Consumption

Energy consumption patterns in healthcare institutions vary depending on a number of factors, including the size and type of facility, the climate, and the types of services provided. However, some general trends can be observed. For example, hospitals are typically the most energy-intensive healthcare facilities, followed by clinics and other outpatient facilities. Hospitals have a number of specific energy needs, including [7]:

- *Lighting:* Hospitals require a high level of lighting for patient care, surgery, and other procedures.
- Hospitals need to regulate their heating and cooling systems to ensure a comfortable environment for both patients and staff members.
- Medical devices like MRI machines and CAT scanners consume significant amounts of energy.
- *Electronic data management:* Hospitals use a variety of electronic systems to manage patient records, medical equipment, and other administrative tasks.

Interconnection Between Waste Generation and Energy Consumption [8]

There is a close interconnection between waste generation and energy consumption in healthcare facilities. For example, the incineration of medical waste requires energy. Additionally, the transportation of waste to disposal facilities also consumes energy.

Reducing waste can indirectly contribute to lowering energy usage and, subsequently, decrease the carbon footprint of healthcare facilities. For instance, recycling medical waste aids in diminishing the volume of waste requiring either incineration or transportation.

TELEMEDICINE: SUSTAINABLE HEALTHCARE SOLUTION

Definition and Components

Telemedicine involves providing healthcare services from a distance using telecommunications technology. It can be used to provide a variety of services, including [9]:

- *Teleconsultation:* Teleconsultation is a remote meeting between a patient and a healthcare provider using video conferencing or other technologies.
- Remote monitoring entails the utilization of wearable devices and similar technologies to observe a patient's vital signs and other health-related information. This information can then be transmitted to a healthcare provider for assessment and evaluation.
- Digital health records refer to electronic copies of a patient's medical documentation. These records can be remotely accessed by healthcare providers, enabling patients to receive medical attention from any location globally.

Environmental Impact Reduction

Telemedicine can help to reduce the environmental impact of healthcare in a number of ways [10]:

- *Reduced need for physical infrastructure:* Telemedicine can help to reduce the need for physical healthcare facilities, such as hospitals and clinics. This could result in reduced energy usage and mitigated environmental effects.
- *Minimized patient travel:* Telemedicine can help to minimize patient travel by providing remote access to healthcare services. This can lead to a decrease in carbon emissions and other air pollutants.
- *Enhanced resource management:* Telemedicine aids in resource optimization by diminishing reliance on in-person appointments and other resource-intensive care methods. Consequently, this could result in reduced energy consumption, waste production, and environmental consequences.

Technological Innovations

Modern advancements like the Internet of Things (IoT), Artificial Intelligence (AI), and Blockchain are becoming progressively significant in the realm of telemedicine. These innovations present various potential advantages for sustainability, encompassing:

- *IoT devices* enable the remote collection and transmission of patient data, facilitating personalized care delivery and real-time health monitoring. Additionally, IoT devices can be used to automate tasks and improve the efficiency of healthcare delivery, leading to a decrease in energy consumption and other environmental impacts.
- *AI* can be utilized to examine patient data, detecting patterns and trends. This information can be used to improve the diagnosis and treatment of diseases, as well as to develop preventive strategies. Additionally, AI can be used to automate tasks and improve the efficiency of healthcare delivery, leading to a decrease in energy consumption and other environmental impacts.
- *Blockchain:* Blockchain, a distributed ledger technology, offers a secure method for storing and exchanging patient data. Its implementation enhances the security and confidentiality of patient information and facilitates seamless data sharing among healthcare providers and other involved parties, potentially resulting in a more effective and eco-friendly healthcare system.

Here are some examples of telemedicine innovations that are helping to reduce the environmental impact of healthcare:

- *Remote patient monitoring:* Remote patient monitoring programs use wearable devices and other technologies to track patients' vital signs and other health data remotely. Afterward, this data is sent to a healthcare provider for examination and assessment. Remote patient monitoring can help to identify potential health problems early on, when they are most treatable, and can reduce the need for hospitalization and other resource-intensive forms of care.
- *Telehealth platforms* enable patients to remotely connect with healthcare providers using video conferencing or alternative technological means. This can help to reduce the need for patients to travel to and from healthcare facilities, which can lead to a decrease in carbon emissions and other air pollutants.
- *Virtual reality (VR) and augmented reality (AR):* VR and AR are being used to develop new telemedicine applications, such as virtual clinics and surgical training simulators. These applications can help to improve the quality and efficiency of healthcare delivery while reducing the environmental impact.

CASE STUDIES AND IMPLEMENTATION CHALLENGES

Successful Telemedicine Initiatives

Case Study 1: Project ECHO in New Mexico, USA

Project ECHO is a telemedicine initiative that connects primary care providers in underserved areas with specialists at academic medical centers. This allows primary care providers to receive expert advice

on complex cases without having to refer patients to distant hospitals. Project ECHO has been shown to improve healthcare outcomes and reduce costs in New Mexico. For example, a study found that Project ECHO reduced the number of referrals to specialists by 38% and saved the state an estimated \$11 million per year.

Case Study 2: Rwanda's Digital Health Program

Rwanda's Digital Health Program is a comprehensive telemedicine initiative that aims to provide universal healthcare access to all Rwandans. The initiative employs a range of technologies such as mobile phones, telemedicine booths, and electronic health records. Rwanda's Digital Health Program has been acknowledged for enhancing healthcare accessibility and lowering mortality rates. For instance, it has contributed to raising the percentage of women delivering babies in healthcare facilities from 51 to 93%.

Case Study 3: India's eSanjeevani Telemedicine Platform

India's eSanjeevani Telemedicine Platform is a government-run telemedicine platform that provides free teleconsultation services to citizens. The platform has over 100,000 registered doctors and has served over 100 million patients since its launch in 2020. eSanjeevani has been credited with improving access to healthcare and reducing the burden on hospitals. For example, a study found that eSanjeevani reduced the number of patients visiting hospitals by 20%.

In 2020, the healthcare company conducted a total of 3,015,530 medical appointments. Out of these, 640,122 were digital (495,913 video appointments and 144,209 telephone appointments), averaging 3,700 digital appointments daily. This digital shift prevented 1,957 net tons of CO₂ emissions (Figure 2). Moreover, patients digitally accessed and downloaded 3,064,646 medical reports, resulting in the avoidance of approximately 4,698 net tons of CO₂ emissions. Collectively, these digital solutions spared 6,655 net tons of CO₂ emissions in 2020.

Challenges and Solutions

Regulatory challenges

One of the biggest challenges to the adoption of telemedicine is regulatory barriers. Numerous nations have established laws and regulations to oversee the provision of healthcare services. These laws and regulations may not be adapted to telemedicine, which can create challenges for providers and patients.

Technological Challenges

Telemedicine relies on a variety of technologies, such as video conferencing, remote monitoring devices, and electronic health records.

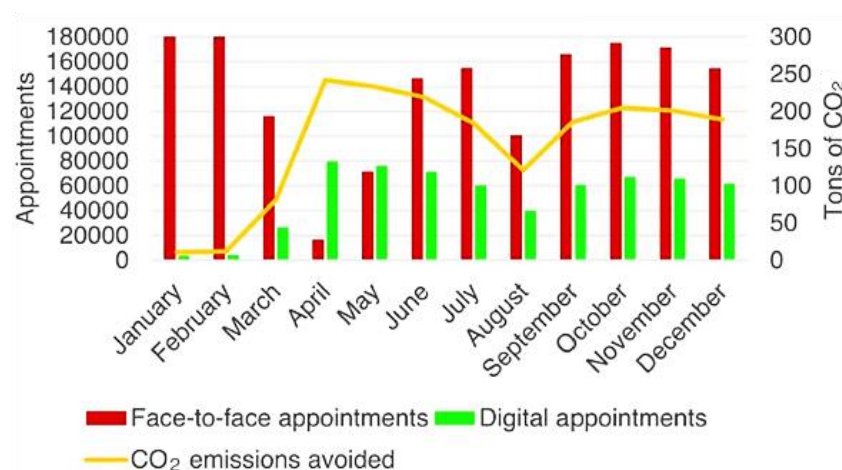


Figure 2. Appointments vs Months and CO₂ emission.

Implementing and utilizing these technologies can be costly and intricate. Moreover, not all patients have the means to access the required technologies.

Ethical Challenges

Telemedicine presents several ethical dilemmas, including concerns regarding the confidentiality and protection of patient data, ensuring patients' informed consent, and maintaining the standard of care delivered remotely.

Solutions and Best Practices

Governments and policymakers can play a role in overcoming the challenges to telemedicine adoption by developing supportive regulations and investing in telemedicine infrastructure. Moreover, healthcare providers can adopt optimal procedures to guarantee the quality and safety of telemedicine services.

Best practices for telemedicine implementation are:

- a. Develop clear policies and procedures for telemedicine services.
- b. Train staff on how to use telemedicine technologies and deliver telemedicine services effectively.
- c. Use secure and reliable telemedicine platforms.
- d. Obtain informed consent from patients before providing telemedicine services.
- e. Provide patients with access to technical support.

FUTURE PROSPECTS AND RECOMMENDATIONS

Telemedicine is a rapidly evolving field with the potential to revolutionize healthcare delivery and reduce the environmental impact of the healthcare sector. Emerging technologies such as IoT, AI, and Blockchain are playing an increasingly important role in telemedicine, offering new opportunities to improve the quality, efficiency, and sustainability of care.

Some of the key prospects for telemedicine include:

- Greater utilization of telemedicine across a broader spectrum of services is anticipated. Presently, telemedicine is employed for diverse services such as primary care, specialty care, and mental health care, yet there remains considerable room for further growth. In the future, telemedicine is expected to be used for an even wider range of services, including chronic disease management, preventive care, and end-of-life care.
- Enhanced incorporation of telemedicine into other healthcare technologies is expected. Telemedicine is progressively being combined with electronic health records (EHRs) and remote patient monitoring (RPM) systems. This integration is leading to more seamless and efficient care delivery. In the future, telemedicine is expected to be even more integrated with other healthcare technologies, such as artificial intelligence (AI) and blockchain.
- Improved access to care for underserved populations. Telemedicine has the potential to significantly improve access to care for underserved populations, such as people living in rural areas, people with disabilities, and people with low incomes. In the upcoming years, it is anticipated that telemedicine will have a growing significance in closing the digital gap and securing universal access to high-quality healthcare.

To accelerate the adoption of telemedicine and achieve its full potential, the following recommendations are made:

- Governments and policymakers should develop supportive telemedicine regulations. This includes clarifying the requirements for telemedicine licensure, reimbursement, and data privacy.
- Healthcare providers should invest in telemedicine technologies and training for staff. This will aid in guaranteeing the effective and safe delivery of telemedicine services.
- Technology companies should continue to develop innovative telemedicine solutions. This includes developing more affordable and user-friendly technologies, as well as technologies that address the needs of underserved populations.

- Efforts should be made to raise public awareness and comprehension of telemedicine. This will help to reduce concerns about the quality and safety of care, and encourage people to use telemedicine when appropriate.

CONCLUSION

Telemedicine is a promising solution for reducing the environmental impact of healthcare while improving access and quality.

By utilizing information technology, telemedicine can contribute to establishing a healthcare system that is both sustainable and equitable for all. Governments can play a leading role in promoting telemedicine by developing supportive policies and regulations, investing in telemedicine infrastructure, and supporting research and development in telemedicine technologies. Healthcare providers can play a vital role in adopting and implementing telemedicine solutions, and in training their staff to deliver telemedicine services effectively and safely. Technology companies can play a key role in developing innovative and affordable telemedicine solutions that meet the needs of patients and providers.

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