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Digital Health Transformation and Management on Sustainable Development for Post-Pandemic Recovery: A Literature Review

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Abstract

Introduction: The COVID-19 pandemic has accelerated the digital health transformation, emphasizing the importance of digital technology in addressing global health crises and recovery, with significant implications for the Sustainable Development Goals (SDGs). This literature review examines the impact of digital health on sustainable development in the post-pandemic era, identifying trends, best practices, and providing policy recommendations. It explores the integration of technologies like telemedicine, AI, and IoT in healthcare, which enhance access, quality, and efficiency. However, challenges such as interoperability, data security, and the digital divide remain. Effective management, cross-sector collaboration, and continuous evaluation are essential for successful implementation, offering opportunities for improved healthcare quality and innovation.

Research Methods: This research is a descriptive and analytical literature review that utilizes data from scientific journals, research reports, news articles, government policies, and relevant organizational documents. Data were collected through literature searches in databases and analyzed using thematic analysis to identify main themes and subthemes, ultimately synthesizing the findings to create a conceptual framework.

Finding/Results: The literature review finds that while digital health transformation, accelerated by the COVID-19 pandemic, has significantly improved healthcare access, quality, and system efficiency, achieving Sustainable Development Goals (SDGs) faces challenges related to interoperability, data security, the digital divide, and regulatory frameworks, which require strategic leadership, cross-sector collaboration, and continuous evaluation to overcome.

Keywords: Digital Health Transformation, Management, Sustainable Development Goals, Post-Pandemic Recovery

INTRODUCTION

The COVID-19 pandemic has catalyzed a profound transformation in global healthcare systems, emphasizing the urgent need for innovative solutions to enhance service delivery and patient care. As traditional healthcare models faced unprecedented challenges, the adoption of digital health technologies became not only a necessity but also a strategic imperative for sustainable development. This literature review aims to explore the intersection of digital health transformation and sustainable management practices in the context of post-pandemic recovery. Digital health encompasses a broad spectrum of technologies, including telemedicine, mobile health applications, artificial intelligence, and big data analytics. These innovations have revolutionized the way healthcare services are delivered, facilitating remote consultations, improving patient engagement, and enabling real-time data management (Yeung et al., 2023). The World Health Organization (WHO) defines digital health as the integration of digital technology into health systems to enhance health outcomes, thereby broadening the scope of traditional eHealth initiatives to include advanced computing and connectivity solutions (Abdolkhani et al., 2022).

In light of the Sustainable Development Goals (SDGs), particularly Goal 3 which aims to ensure healthy lives and promote well-being for all at all ages, the role of digital health technologies is increasingly recognized as pivotal. The pandemic has highlighted significant disparities in healthcare access and delivery, particularly in low-resource settings. Therefore, leveraging digital health can address these inequities by providing innovative solutions that enhance accessibility and efficiency in healthcare delivery (Novillo-Ortiz et al., 2018).

Moreover, this review will discuss the implications of digital health transformation for management strategies within healthcare organizations. Effective management practices are essential for integrating these technologies into existing systems while ensuring that they align with broader sustainability goals. The need for robust policy frameworks, regulatory compliance, and workforce training emerges as critical components for successful implementation.

LITERATURE REVIEW

Digital Health Transformation

When the COVID-19 pandemic was announced globally in 2019, the delivery and organization of health care were thrown into a state of fast disruption. The adjustment was related with staff deployment, patient isolation, staff well-being protection, and public health education and attempts to minimize or delay the propagation of the virus. The epidemic most certainly has expedited the acceptance of digital health implementation. Due to the availability of many innovations and the urgent need for treatment and prevention, digital health is likely to play an increasingly important role in the future and even the post pandemic age. The epidemic caused extensive and quick adaptation to previously limited or underutilized kinds of technology, which has transformed the ways clinicians and patients communicate (Abdolkhani et al., 2022).

The understanding of health, treatment, diagnosis, and communication has evolved to new levels. The Fourth Industrial Revolution has impacted research, policymaking, and business activities among healthcare and management researchers and practitioners. These events have significantly altered the administration and organization of health systems (Drago et al., 2023). Telemedicine, AI, big data analytics, and mobile surveillance apps have been widely used to diagnose, prevent, monitor, and treat patients globally (Omboni et al., 2022).

The World Health Organization (WHO) defines digital health technologies as the knowledge and practice of using digital technology to improve health outcomes. Digital health broadens the scope of eHealth to encompass digital users and a wider range of smart and connected devices. It also includes additional uses of digital technology for health, such as the Internet of Things (IoT), advanced computing, big data analytics, artificial intelligence (including machine learning), and robotics. Importantly, in the context of digital health technologies, several terms such as eHealth (electronic health), telemedicine, and mHealth (mobile health) have been widely used, unfortunately, on some occasions with overlapping meaning, underlining the necessity of using more precise scientific language reflecting the subtle differences between such relevant terms. In keeping with this, the term "digital health" was created to refer to the widest range of applications of digital technologies in the context of health. Although it has its roots in

electronic health, it also includes related fields like artificial intelligence, genomics, and "big data" applications. Furthermore, mHealth is seen as a subset of eHealth that refers to the use of wireless mobile technologies for public health (gaining particular momentum with the widespread adoption of smartphones and corresponding apps), and telemedicine is a term reflecting the use of electronic communications and information technologies for the remote provision of health care services. eHealth is frequently defined as the use of information and communications technology in support of health. For instance, telemedicine has become a popular topic of conversation in the scientific, political, and medical communities lately. This is because during the COVID-19 global pandemic, most of the world's population was subjected to varying degrees of home quarantines, community lockdowns, and reduced access to medical care (Yeung et al., 2023).

Telemedicine refers to the use of technology to provide medical treatment and healthcare services remotely. The prolonged crisis has led to increased use of telemedicine technologies. The consumer's perspective and necessary investments have been key factors pushing the sector. Telemedicine has been utilized for many years. Data shows that it can improve medical performance and health outcomes for patients. Telemedicine can minimize hospitalizations and expenditures for healthcare players, including individuals and organizations. Telemedicine is becoming more popular as physicians recognize its benefits, patients have greater access to therapy, and payers perceive a decrease in the cost of care (Drago et al., 2023).

According to Smith et al. (2020), implementing telehealth requires a considerable shift in management and reconsidering current medical care models. The reliance on individual practitioners to lead telehealth is not a sustainable method to its expansion. Telehealth adoption necessitates a multi-system approach. The most effective strategy to ensure that telehealth can be used during an emergency is for all healthcare practitioners to incorporate it into their usual service delivery. This necessitates operating telehealth networks, telehealth policies and procedures, and scalable technology infrastructure in the event of a disaster. One advantage of these technologies is their ability to facilitate communication, which is particularly useful in specialized medical services.

Additionally, adopting practices that reduce COVID-19 preventive expenses while avoiding patient interaction may increase uptake. Telehealth is a disruptive procedure, thus physicians with limited telehealth expertise require strong change-management tactics (Smith et al., 2020).

Health Data Management and Interoperability

Over the last century, disruptive episodes in clinical and biomedical research have resulted in significant changes to health data management systems. This is owing to a number of medical advancements, as well as the necessity to incorporate big data analytics and the Internet of Things (IoT) into a real-time smart health information management system. Furthermore, the needs of patient care have developed over time, allowing for more precise prognoses and diagnoses. The concept of health data management systems has evolved throughout the past century. With the transfer of medical records from paper charts to electronic health records (EHRs), health data management has experienced disruptive changes in order to deliver more accurate and better patient care while also making meaningful use of these resources. This change is supported by advancements in information technology, which led to the creation of numerous concepts for health data management systems. The introduction of EHRs altered the health care business by expanding services, improving patient care quality, and boosting real-time data access, resulting in a diverse range of health data management systems (Ismail et al., 2020).

The concept of EHRs is that they provide a longitudinal perspective of a patient's medical history over the course of his or her life, as generated by one or more health care providers or medical organizations providing treatments to that patient. These comprehensive and summary records include the patient's demographic and biographical information, prior and current diagnoses and treatments, progress notes, laboratory and radiological results, allergies, and immunizations. With improvements in technology and the need to provide better and more efficient health care, health data management systems have moved from a computer-based approach to client-server-based, cloud-based, Internet of Things (IoT), and finally blockchain-based alternatives. With the rise of big health care data and the recognition that medical data may be used for governance and research, it is becoming increasingly vital to integrate big data analytics into health data management systems (Ismail et al., 2020).

However, this introduces new issues of data gathering and pre-processing from numerous sources to produce insights, data security, and privacy to deal with an increasing number of data breaches and hacker incidents. A client-server-based health data management system was established to meet the need for real-time data access as well as medical record data and exchange. This method enables patients and healthcare practitioners to access medical data via the internet using a mobile device or a desktop computer. However, it suffers from single point of failure, data fragmentation, system vulnerability, insufficient scalability, and significant data security and patient privacy problems. To reduce infrastructure costs and manage data fragmentation, medical organizations and health care providers migrated to a cloud-based system (Ismail et al., 2020).

Integration of Digital Tools into Health Systems

Doctors and patients have shown support for an integrated model of care, which consists of holistic, patient-centered systems that allow for clear, effective communication between clinicians and patients at all levels of care. Integrated care provides for the simultaneous treatment of both physical and mental health issues, facilitating the transition of healthcare from reactive to preventative. Digital Health is critical to the transformation of the current system to a more integrated one since it enables interoperability, data visualization, and sharing where appropriate. While the desire for integrated care and the use of digital health is not new, the COVID-19 epidemic has hastened the discovery of new options for effective implementation (Shah et al., 2022).

A major impediment to the successful application of digital health technology is the continued emphasis on technology in isolation, which is at odds with the realities of complicated health and care systems. Digital health technology must be designed from a systems approach. A systems view looks at how technology fits into the larger healthcare system, where success is determined by interactions with people, other IT systems, the physical environment, and the organization of clinical and administrative operations. Successful integration of digital health technologies into complex clinical systems necessitates a shift away from a limited and limiting technological focus and toward a systems viewpoint, which must be reflected in the technology's

design, implementation, and evaluation. Practitioners must be given significant tools and guidance in order to manage and monitor the operation of digital health technologies, as well as ask the proper questions of developers. Another example is the recently released British Standard BS 30440, which describes an auditable validation framework for healthcare AI (Sujan, 2023).

Technology, like the digitization of other human capital-intensive industries, can allow trained personnel to focus on more technically sophisticated tasks while increasing access and operating efficiency. However, in order to reach this goal, the current and growing workforces in health and social care must be comfortable with data and technology (*Integrating Social Care into the Delivery of Health Care*, 2019). AI and machine learning have the potential to enhance healthcare by enhancing community health, remote care, early detection, and resource utilization. AI systems may use vast datasets to discover trends and forecast patient outcomes, enabling healthcare providers to give more accurate diagnoses and individualized treatments. AI in healthcare includes computer-aided diagnosis (CAD) systems that utilize machine learning algorithms to analyze medical pictures and help radiologists discover problems. AI can examine EHRs to predict patient outcomes and identify those at risk for specific illnesses. However, the application of artificial intelligence in healthcare creates ethical and privacy concerns. Concerns have been raised concerning how AI algorithms may reinforce biases and discriminate against specific patient groups. Concerns have been raised regarding patient data security and the risk of unauthorized access or misuse (Shipu Debnath, 2023).

Mobile health apps are one example of digital tools that health providers use. Mobile health apps offer patients easy access to health information, self-management tools, and communication channels with physicians, transforming their healthcare experience. Patient engagement, which involves people in healthcare decisions and treatment plans, is vital for improving health outcomes and quality. Patient engagement encompasses patients' active involvement in their healthcare experience. It includes activities such as obtaining health information, making treatment decisions, following treatment programs, and managing chronic illnesses. Engaged patients receive better health outcomes, more satisfaction with care, and lower healthcare expenditures. Mobile health apps encourage patient engagement by providing tools and resources to manage their health. These apps allow patients to track health parameters,

monitor progress, and communicate with healthcare providers. Mobile health applications provide tailored health information and services, allowing patients to make informed decisions about their health and treatment alternatives. Mobile health apps have been shown in numerous studies to improve health outcomes across groups and situations. Apps can help improve medication adherence, manage chronic illnesses, promote healthy behaviors, and increase communication between patients and providers. Several researches have demonstrated that mobile health apps improve health outcomes.

A study published in Diabetes Care found that individuals with type 2 diabetes who used a smartphone app to track their diet and exercise habits lost more weight and improved their glycemic control than those who did not. A study published in the American Journal of Preventive Medicine found that patients who used a smartphone app to track their physical activity had higher daily step counts and better cardiovascular fitness than those who did not use the app. Mobile health apps can improve healthcare delivery by offering easy access to health information, monitoring tools, and behavior modification support. However, there are obstacles and constraints that must be addressed for these apps to be as effective as possible (Chioma Anthonia Okolo et al., 2024).

The role of digital health in Sustainable Development Goals

The United Nations (UN) has twice agreed to a precise agenda that must be followed by all 189 member states in order to advance global development targets. The Sustainable Development Goals (SDGs), the current framework for 2015–2030, replaced the Millennium Development Goals (MDGs), which were set for 2000–2015, as the initial accord. The 17 SDGs were enacted to build on the MDGs' achievements. SDG 3 intends to "ensure healthy lives and promote well-being for all at all ages" and includes numerous specific targets to achieve this goal. However, war and political instability have a negative impact on the healthcare system, and the casualties of war go well beyond the battlefield. Conflict, a social determinant of health, greatly contributes to health disparity by reducing the quality and delivery of care throughout the entire system. The SDGs push the global community to reassess established health-care delivery practices. Traditional on-the-ground health facilities, with access to resources and an adequate workforce, are uncommon in

conflict-affected areas, particularly those with current violence and severe political instability. According to projections, nearly half of the world's poorest population would live in conflict-affected areas by 2030. It is clear that in order to meet the goals of SDG 3, governments and practitioners must be willing to reconsider healthcare delivery. The convergence of medicine and technology has the opportunity to use innovative and low-cost platforms in vulnerable places to increase global and local capacity. To "ensure healthy lives and promote well-being for all at all ages," low-income countries must acquire some level of independent capability. In order to achieve global health goals, digital health technology can facilitate access to the internet, personal health and non-health data, and environmental data. Fragile states stand to benefit greatly from the deployment of digital health technologies such as telemedicine, electronic medical records (EMRs), wearables, mobile health (mHealth), and creative software (Asi & Williams, 2018).

While acknowledging that there are disparities in this area between nations, it is also true that the telecommunications industry advanced significantly between 2000 and 2015. In particular, the number of mobile phone subscriptions worldwide increased from 738 million to 7 billion, the percentage of people using the Internet globally increased sevenfold from 6.5% to 43%, and the percentage of people living in areas serviced by 2G mobile cellular networks increased from 58% in 2001 to 95% in 2015. All of these changes have allowed us to go about our daily lives in a new way, which has had a direct impact on the health sector, influencing how we approach our health throughout our lives, how we communicate with health professionals, and how we access and receive health services at various levels of care. New wireless technology advancements are offering chances to change the healthcare industry.

As the healthcare system transitions from treating individual patients' acute health problems to managing population-based diseases and prevention, these new technologies help address issues related to geographic accessibility, make it easier to provide appropriate interventions, lower the cost of those interventions, and even help increase public knowledge of how to treat illnesses and encourage healthy lifestyles, all of which support patient empowerment. These and other digital healthcare initiatives to meet the SDGs have problems that extend beyond the adoption of technology to include social, cultural, and organizational aspects, as outlined by the WHO and its regional office in the Americas, the Pan American Health Organization. These

include the necessity for a qualified workforce capable of implementing digital health solutions, as well as effective governance and finance. To overcome these barriers, work must take an interdisciplinary and cross-sectoral approach, bringing together all of the major actors in the digital health ecosystem: governments, international organizations, health service institutions, academia, research centers, and public and private industry. First and foremost, nations must establish and put into place public-facing governance mechanisms for digital health. The development of national strategies and policies that demonstrate potential forms of inter-sectoral cooperation and a "vision of state" is required in order to achieve this. These strategies should involve healthcare professionals from the outset, look for sources of funding, and modify academic curricula to reflect the changes brought about by the introduction of ICTs. In addition, they ought to address the necessary legal changes pertaining to the regulatory elements of digital health (data protection, privacy, and confidentiality, individual patient rights, and data responsibility) (Novillo-Ortiz et al., 2018).

Environmental and Equity Considerations

Digital health can also help to improve environmental sustainability by eliminating the need for physical travel and the infrastructural strain on healthcare systems. This supports climate action goals by lowering the carbon footprint of healthcare services. Many governments are undertaking carbon-reducing plans and activities to combat climate change. In this perspective, public procurement is viewed as an important tool for accelerating the green transition since it can, for example, include environmental norms and standards in public tenders. Procurement by the government is the method used by a public service to obtain products, services, works, and other supplies, usually through a contractual arrangement following public competition. Healthcare systems, which account for around 4.6% of global greenhouse gas (GHG) emissions, are required to reduce their environmental effect in order to better match with their goal. However, due to the particular nature of healthcare, the green transition confronts numerous hurdles, including meeting strict safety, efficacy, and efficiency standards in order to safeguard patients and provide quality care. The design of eco-friendly health technologies that meet public procurement standards is extremely problematic, because health innovators fear that additional

environmental criteria may impair the quality and safety of care for patients and increase costs for healthcare systems (Alami et al., 2023).

The most well-known type of telemedicine is digital consultation, which includes both teleconsultation and video consultation. Digital consultation enhances the patient experience and empowers the patient to manage his or her own care. Satisfaction levels are really high. It also reduces carbon dioxide (CO2) emissions by eliminating the need to go to a surgery for a face-to-face session, and while the digital procedure consumes more energy, the benefits of avoiding travel significantly exceed the drawbacks. CO2 is a major greenhouse gas that traps heat in the atmosphere and contributes significantly to climate change. Climate change has an influence on every continent and poses a risk to both human health and the environment. Human activities have been responsible for nearly all of the recent increase in greenhouse gas concentrations in the atmosphere. The transportation sector accounts for the majority of greenhouse gas emissions, which are mostly caused by the combustion of fossil fuels in automobiles, trucks, ships, trains, and airplanes. Electricity production accounts for the second greatest share of greenhouse gas emissions. Although health-related transportation accounts for only 1.5% of overall trips, digital health could assist address both challenges, particularly telemedicine programs, due to the possibility to eliminate patient travel. Digital consultations have increased significantly since 2020, allowing for continuity of care amid the COVID-19 pandemic. During the testing period, it showed to be a safe and effective alternative to traditional care. Telemedicine, in addition to being a highly effective tool in rare situations, offers benefits that will cause us to reconsider its usage in day-to-day care processes outside of the exceptionality of a pandemic. These advantages benefit the patient, the practitioner, and the health-care system. In 2020, users highlighted its ease of use, flexibility, comfort, and savings in time and money by reducing travel, with the consequent environmental impact achieved by avoiding CO2 emissions, as well as greater security by reducing the risk of contagion throughout the various COVID-19 waves or other infectious disease. These benefits were also observed by health care staff, who reported enhanced work-life balance due to remote working and deemed digital tools a well-accepted health care alternative (Morcillo Serra et al., 2022).

Management strategies for post pandemic recovery

Public Private Partnership

Historically, most countries had separate private and public health sectors. According to the argument, the private sector mostly serves the wealthy in a country, while the government serves those who cannot afford to pay for services. Recent research suggests that this model may not exactly reflect reality. The private sector is often the primary provider of treatment for the poor, while the government system often prioritizes services for the wealthy. Public-Private Partnerships (PPPs), have become a vital tool for promoting innovation in the global health industry. This assessment highlights the importance and influence of the lessons that have been learnt from various PPP models around the world. PPPs in healthcare innovation involve working together between public and private sectors, as well as occasionally non-profit groups, to address issues such scarce infrastructure, knowledge, and resources while utilizing each sector's advantages. It is impossible to overestimate the importance of PPPs in the healthcare industry, especially in light of the intricate and constantly changing global healthcare concerns. PPPs enhance the resources available for healthcare innovation by enabling the mobilization of financial, technological, and human resources from both the public and private sectors. These partnerships offer many important advantages. PPPs enable the development and widespread acceptance of creative solutions to healthcare problems by encouraging cooperation amongst a variety of stakeholders, improving the efficacy and efficiency of healthcare delivery. In the healthcare industry, public-private partnerships, or PPPs, have developed into a variety of models. These models are customized to address particular healthcare issues and make use of the combined knowledge and resources of public and private organizations. Research-focused Public-private partnerships bring together government agencies, academic institutions, pharmaceutical corporations, and other stakeholders to enhance medical research and develop new treatments or technology. These agreements enable an exchange of scientific knowledge, talent, and infrastructure, accelerating the discovery and development of novel healthcare solutions. Service Delivery Public-private partnerships (PPPs) are cooperation between public healthcare providers and commercial entities to improve healthcare delivery. These collaborations might cover things like building infrastructure, managing healthcare systems, and offering medical services.

Navigating complicated legal procedures and regulatory frameworks is a major hurdle in PPP implementation. Diverse legal systems can make it difficult for people to work together and innovate, especially in global partnerships. Furthermore, strict rules could impede the timely delivery of healthcare innovations to patients by delaying their approval and implementation. Establishing open communication channels with regulatory organizations and actively engaging in dialogue can help to reduce regulatory barriers. PPP stakeholders must work closely with regulators to successfully handle legal difficulties. Furthermore, advocating for regulatory reforms to simplify approval processes and standardize standards can stimulate innovation and speed the implementation of healthcare solutions (Ebulue et al., 2024).

Workforce training and Capacity building

Health service managers require the ability to lead and manage the digital health transformation as well as the capabilities and necessary competences to enable data-driven, strategic, and operational decision-making in the quickly evolving, digitally connected healthcare environment. During this time of systemic change, health care managers must meet the challenges presented by the remarkable rise in digital health literacy and demonstrate proficiency in designing and managing digital tools and technology in this dynamic environment. Success in healthcare innovation and transformation requires a healthy workforce with the necessary understanding and skill sets, which does not happen overnight and is an ongoing process of improvement. Using the introduction of electronic health records (EHR) as an example, after being widely implemented in the healthcare system, particularly in the hospital sector for more than a decade, mounting evidence indicates that EHRs have not been adequately utilized by clinicians to guide clinical decision-making. The three main causes of the low adoption of EHRs were clinicians' inexperience of the tools' advantages, their regular encounters with access issues, and their perception of the tools' lack of efficacy and efficiency (Brommeyer&Liang, 2022).

The basic principles of workforce policy, which includes authorized resources and funding, as well as concurrent activities at the system, institution, organization, and person levels, should guide and promote the development of the health workforce as a whole. The Australian Digital Health Agency (ADHA) is responsible for developing the National Digital Health Workforce and

Education Roadmap as well as providing targeted financing and national policy guidance for digital health in Australia. The roadmap makes it very clear that the healthcare workforce has to acquire a range of digital literacy and baseline competencies. It also implies that the digital knowledge and skills needed will vary depending on the various roles in digital health and the needs of the healthcare system's service delivery. Two of the profiles, 'leadership and executive profile' and 'the business, administration, and clinical support digital profile', are especially important because capable leaders and managers of a digitally-enabled workforce are critical factors in successfully implementing and managing digital health transformation. In addition to governmental guidance and incentives, the supply of skill development for the health workforce is contingent on the collaborative efforts of university programs, professional institutes, and individual healthcare organizations. Digital health transformation requires competent executives capable of leading and managing, as well as relevant competences that allow for data-driven, strategic, and operational decision-making. Health care managers must face the challenges of extraordinary development in digital health literacy during this moment of systemic transition, as well as be adept in planning and managing the digital tools and technology throughout this changing landscape (Brommeyer & Liang, 2022).

Policy Frameworks and Regulation

Digital transformation is an ongoing process that, with the right infrastructure and skills, can open up new opportunities in the health care sector. It is anticipated that in the upcoming years, the patient will play a more central role in health transformation, adopting the role of the "health service consumer" and seeking control over their own health care. The demands and aspirations of this new "consumer of health services," who will demand improved experiences with the primary attributes of personalization, comfort, speed, and immediacy in the provision of services, will transform the healthcare sector. For digital health technologies to be successfully integrated into healthcare systems, it is essential that they adhere to established regulatory standards (Stoumpos et al., 2023).

Digital Health Technologies (DHTs) enable trial participants to record data (e.g., biomarkers, daily activities, sleep, vital signs) from any location, including home, school, work, and

outdoors. The DHT may collect data passively or by active interaction with participants. DHTs can transport data directly to authorized parties, including investigators, sponsors, and others, while maintaining data anonymity or masking as needed. In many countries, regulatory authorities such as the United States Food and Drug Administration (FDA) and the European Medicines Agency (EMA) provide standards for the approval and monitoring of digital health devices and applications. These regulations frequently address issues like clinical efficacy, data security, and user safety. Compliance with these standards protects patients from potential danger while also ensuring that technologies satisfy basic quality norms (U.S. Department of Health and Human Services Food and Drug Administration, 2023).

Big data technology adoption in the healthcare industry has a number of opportunities and advantages, but it also presents certain difficulties. The security and privacy of sensitive data are indeed becoming more and more of a problem as a result of a number of expanding trends in healthcare, including cloud computing, wireless networking, clinician mobility, and health information interchange. In addition, healthcare institutions discovered that a technology-centric, bottom-up, reactive approach to defining security and privacy needs is insufficient to safeguard the company and its clients. Healthcare organizations must take proactive efforts to prevent sensitive information breaches and security events, while also considering future security and privacy concerns. In the US, the non-profit Indiana Health Information Exchange connects over 90 hospitals, community health clinics, rehabilitation centers, and other healthcare providers through a secure technology network. It enables medical information to follow patients across many doctor offices or hospitals.

At the most recent 2017 Annual Meeting of the American College of Medical Genetics and Genomics (ACMG), Sophia Genetics, a global leader in data-driven medicine, announced that African hospitals have begun using its artificial intelligence to improve patient care, following the lead from Europe, Canada, Australia, Russia, and Latin America. Automations have improved patient care workflow and cut costs, but they also raise the risk of security and privacy breaches as healthcare data grows. In 2016, CynergisTek published Redspin's 7th annual Breach research: Protected Health Information (PHI). According to this research, there was a 320% rise in hacking assaults targeting healthcare providers in 2016, and 81% of records compromised that year were

primarily the result of hacking attempts. Furthermore, the most common threat to hospitals has been determined to be ransomware, which is characterized as a kind of malware that encrypts data and holds it captive until a ransom demand is satisfied. Consequently, it is imperative that healthcare institutions adopt data security strategies that fulfill regulatory requirements and safeguard valuable assets. Healthcare businesses must manage and preserve personal information, address risks, and comply with data protection laws. Guidelines for data protection, such as consent requirements, data encryption, and breach notification procedures, are established by regulations like the General Data Protection Regulation (GDPR) in the European Union and the Health Insurance Portability and Accountability Act (HIPAA) in the United States. These regulations guarantee the responsible management of patient data and the protection of individuals' privacy even as the use of digital health solutions spreads (Abouelmehdi et al., 2017).

RESEARCH METHODOLOGY

This research is a descriptive and analytical literature review that utilizes data from scientific journals, research reports, news articles, government policies, and relevant organizational documents. Data were collected through literature searches in databases and analyzed using thematic analysis to identify main themes and subthemes, ultimately synthesizing the findings to create a conceptual framework. Using Google Scholar, PubMed, Scopus, ScienceDirect and Emerald Insight, as search engines and databases for the selected researches in our research were chosen on the basis of medical and management background. The literature review involved a thorough analysis of structured knowledge, ideas, or findings from previous researches relevant to a specific topic.

Our study is based on a literature review of studies related to medical sectors in association to digital transformation and management. We eliminate based on repeating the same sectors or duplication of study until arrive to 20 study literature reviews, and picked the past five years researches, in various dealings with digital health transformation and management. The database search yielded a number of articles, which were then checked for duplication. Following this, the

reviewer conducted a screening of titles and abstracts, resulting in the selection of 7 articles relevant to the topic to be discussed. These articles were subsequently reviewed for quality and discussed in this literature review. To further elaboration, the process involved a meticulous selection of articles to ensure their relevance and quality. After eliminating duplicates, the reviewer carefully assessed the titles and abstracts to filter out articles that best addressed the research topic. The final selection of 7 articles underwent a rigorous quality evaluation to ensure that they met the standards required for inclusion. This thorough review process is essential for providing a comprehensive and accurate analysis of the current state of research on the topic at hand.

We first have to get further elaboration about digital health and its transformation especially for post COVID-19 pandemic recovery. Secondly, by collaborating digital tools into health system and management, we elaborate the integration of digital tools into the health system and most importantly its role in Sustainable Development Goals (SDGs) and even for management strategies. Thirdly, the research compares few researches to gain more insight and explanation in relation to digital health transformation and management on SDGs for post pandemic recovery.

RESULT AND DISCUSSION

The database yielded a number of articles, which were then selected to be reviewed, the findings from the selected articles are detailed and discussed in the following sections.

Authors	Title	Method	Results
Biancuzzi, H., Dal Mas, F., Bidoli, C., Pegoraro, V., Zantedes	Economic and performance evaluation of E-health before and after the pandemic era: a literature	The study utilized a structured literature review to explore methods for measuring the economic value and performance of e-Health services pre- and	The literature review reveals a significant gap in the integration of economic and managerial perspectives within the clinical setting of e-Health. Most studies focus exclusively on clinical aspects, highlighting the need for more research into the economic and managerial

chi, M., Negro, P.A., Campostrini, S. and Cobianchi, L., 2023.	review and future perspectives.	post-pandemic. Searches were conducted in Scopus, Web of Science, and Pubmed using terms like “e-health” and “telemedicine,” resulting in 2063, 5136, and 2447 initial results, respectively. After refining the search to include only English journal articles related to medicine, economics, and finance published post-2019, 439 unique articles were identified. Following a review of titles and abstracts, 21 papers were selected for full-text analysis, with 20 deemed relevant. These papers were coded and analyzed using Nvivo software, focusing on author profiles, study locations, sector analyzed, research methodology, clinical disciplines, and e-Health tools used.	impacts of e-Health technologies. This gap reflects the growing role of medical doctors as "hybrid managers" who must handle cost and budget responsibilities, emphasizing the importance of including managerial issues in clinical discussions. Geographically, e-Health appears more advanced in Northern Europe, with fewer quantitative studies from other continents suggesting that Europe is leading in this field. The review also highlights that while the COVID-19 pandemic accelerated the adoption of e-Health tools, there was no significant shift in cost or performance evaluations reported in the literature. The potential of Virtual Hospitals to enhance remote patient care, especially for chronic and elderly patients, is noted, yet there is a need for further research to better understand the effectiveness of different e-Health tools for various pathologies.
Leal Filho, W., Lange Salvia, A., Beynaghi, A., Fritzen, B., Ulisses,	Digital transformation and sustainable development in higher education in a post-pandemic world	The research utilized a questionnaire with 14 questions, covering demographic information, digital transformation deployment, its contribution to SD, and challenges faced. The	The research found that the COVID-19 pandemic significantly accelerated digital transformation in higher education, particularly in teaching, which saw the greatest increase according to 52% of respondents. Research followed with 24%, while outreach and event organization accounted for 11% and 10%, respectively. In terms of digital skills

A., Avila, L.V., Shulla, K., Vasconcelos, C.R., Moggi, S., Mifsud, M. and Anholon, R., 2024.		survey was conducted online via Google Forms using a snowball sampling technique, and responses were analyzed using SPSS for descriptive and inferential statistics. Principal Component Analysis (PCA) was performed to explore how digital technologies influence SD initiatives and innovative opportunities at HEIs. The study assessed the adequacy of the PCA model using measures like the Measure of Sampling Adequacy (MSA), Bartlett's Test of Sphericity, and Cronbach's Alpha for reliability.	development, 64% of respondents reported receiving support from their universities to acquire new skills, while 30% developed these skills independently and 4% paid for their own training. A large majority, 99%, agreed that digital transformation could be applied in the context of sustainable development (SD), addressing environmental, social, and economic aspects. Despite the positive shift towards digitalization, only 32% of respondents indicated they had developed digitally-based business models for sustainability during the pandemic, while 67% had not. The study also highlighted several challenges, with 61% of respondents citing time management during lockdown as a major issue, 59% pointing to the need to learn new digital tools, and 56% mentioning difficulties in continuing academic networking and conferences. These findings demonstrate that while digital transformation has brought notable advancements, significant challenges remain in fully harnessing its potential for sustainable development in higher education
Stoumpos, A.I., Kitsios, F. and Talias, M.A., 2023.	Digital Transformation in Healthcare: Technology Acceptance and Its Applications	The study conducted a systematic bibliographic review using Scopus, Science Direct, and PubMed, covering literature from 2008 to 2021. From 5,847 initially identified articles, 287 were ultimately selected based on relevance to	This study provides several insights into how healthcare systems are adapting to digital technologies. One of the primary findings is the widespread adoption of technologies such as electronic health records, telemedicine, and mobile health (m-health) across various healthcare sectors. For example, 75% of hospitals in the United States have implemented EHR systems, though many healthcare professionals report challenges in using

		digital healthcare topics like e-health, m-health, and telemedicine. The researchers used Webster and Watson's concept-centric method to group articles by themes, including information technology in health, e-health education, technology acceptance, telemedicine, and security. They also employed VOSviewer software to visualize relationships between key concepts, providing a comprehensive analysis of digital healthcare adoption and its impact	these systems effectively due to technological complexity and integration issues. The study also reveals that digital transformation in healthcare remains in its early stages globally, with significant variations across different countries. For instance, while the U.S. has made substantial progress in adopting digital health solutions, other countries, such as the United Kingdom and Australia, have encountered difficulties in implementing large-scale e-health initiatives【16†source】. Moreover, telemedicine and digital health applications have seen rapid growth during the COVID-19 pandemic, providing more accessible healthcare services. However, the effectiveness of these digital solutions varies, depending on the infrastructure and policies in place to support their deployment. The results also highlight the need for improving healthcare professionals' digital literacy and addressing security concerns related to patient data. The development of secure communication systems in telemedicine and health information exchange, is essential to ensure patient confidentiality and trust in digital health systems.
Morcillo Serra, C., Aroca Tanarro, A., Cummings, C.M., Jimenez Fuertes, A. and Tomás	Impact on the reduction of CO2 emissions due to the use of telemedicine.	This study is a retrospective study, evaluated the environmental impact of digital health activities for Sanitas insurance policyholders in Spain in 2020. The study analyzed average travel distances (13 km round trip) and travel	In 2020, Sanitas health care company conducted a total of 3,015,530 medical appointments, with 640,122 in digital format (495,913 video appointments and 144,209 telephone appointments), averaging 3,700 digital appointments per day. This digital shift is estimated to have avoided 1,957 net tons of CO2 emissions. Additionally, patients downloaded 3,064,646 medical reports to their digital health folders, avoiding an estimated

Martínez, J.F., 2022.		modes (car, bus, train) for patients. The study measured CO2 emissions from digital tools such as video consultations and report downloads, while also calculating the emissions avoided from reduced travel and paper use. By subtracting emissions from digital activities from the total savings achieved through reduced travel and avoided printing, the study found that digital consultations significantly lowered carbon emissions, primarily by decreasing patient travel.	4,698 net tons of CO2 emissions. Together, these digital solutions avoided 6,655 net tons of CO2 emissions for the year. Among the digital appointments, 66,510 were with general practitioners and 573,612 with specialists. Of the video appointments, 74.7% were made via mobile phone app and 25.3% via web. The average age of patients using digital appointments was 39, compared to 44 for in-person consultations. Most digital appointments were made by individuals aged 30-39 (54,812 appointments) and 45-54 (47,372 appointments), though patients over 70 made over 18,000 video appointments. Patient satisfaction with digital appointments, measured by the net promoter score (NPS), was high at 62.1%, with 48.7% of customers repeating this communication method. The net carbon saving for digital appointments and download reports were calculated by summing the carbon saving derived from the avoided patient travel and document printing and subtracting the videoconferencing and downloading emissions.
Alami, H., Rivard, L., Lehoux, P., Ag Ahmed, M.A., Fortin, J.P. and Fleet, R., 2023.	Integrating environmental considerations in digital health technology assessment and procurement: Stakeholders' perspectives.	This study involved interviews with 29 stakeholders from a large Canadian health-care center. These stakeholders included clinicians, health technology assessment specialists, managers, and technology providers. The data was collected through a mixed deductive-	The research findings indicate that the integration of environmental considerations into the assessment and procurement of digital health technologies (DHT) is influenced by various factors at the micro, meso, and macro levels. At the micro level, factors include stakeholders' recognition of environmental issues and the suitability of the technology. At the meso level, organizational factors such as culture, policies, and infrastructure can either hinder or support this integration. At the

		inductive analysis approach. The analysis explored factors that impact the integration of environmental considerations in the assessment and procurement of digital health technologies.	macro level, political and regulatory challenges, as well as economic uncertainties, pose major obstacles. The study emphasizes the need for systemic changes to support more environmentally friendly DHT.
Shifa, N., Tiasari, A. and Siregar, K.N., 2024.	Implementation of Digital Health in Addressing Global Threats: Lessons from the Use of Technology during COVID-19 Pandemic in Indonesia.	This study utilized a descriptive design and a systematic literature review methodology. The review involved a analysis of structured knowledge, ideas from previous research relevant to the topic. The literature search was conducted using search engines and databases such as Scopus, ScienceDirect, SAGE, ProQuest, and Portal Garuda. Data collection was carried out by accessing these databases.	This study highlights the significance of adopting digital health solutions in Indonesia during the COVID-19 pandemic. The integration of digital health technologies has been vital for improving the efficiency of the healthcare system, enabling remote medical services, and strengthening epidemic monitoring through mobile applications and contact tracing tools. The partnership between the government and telemedicine platforms has delivered various digital health services, benefiting COVID-19 patients and aiding in resource management. Nonetheless, issues related to infrastructure and equitable access to digital health services remain, especially in remote areas.
Drago, C., Gatto, A. and Ruggeri, M., 2023.	Telemedicine as techno-innovation to tackle COVID-19: A bibliometric analysis.	This study used a two-phase approach. First, a scoping review of articles from the Scopus database (2020-2021) on telemedicine, COVID-19, and innovation. Then, a bibliometric analysis using keyword network analysis and community detection to identify key themes and trends in the literature.	The study found that telemedicine played a crucial role during the COVID-19 pandemic by improving healthcare access, reducing costs, and minimizing hospitalizations. However, challenges such as tech costs, patient privacy, and digital literacy slowed its adoption. Telemedicine highlighted the need for significant organizational changes in healthcare systems. The key themes in the literature, such as the importance of innovation, healthcare management, and the potential for telemedicine to address future pandemics.

During the COVID-19 pandemic, telemedicine emerged as a critical tool for enhancing healthcare access, reducing costs, and minimizing hospitalizations. Studies by Drago et al. (2023) demonstrate that while telemedicine has proven effective in improving healthcare delivery, which helping in fulfilling the Sustainable Development Goals (SGDs) in the effort of enhancing good health and well-being. Telemedicine's role in enhancing healthcare access plays as an innovated way in promoting health, preventing disease, and consultation especially during the COVID-19 pandemic, where people being depressed staying alone in isolation and quarantine can get an opportunity to talk and share their problems with doctors through the means of telemedicine (Koirala et al., 2021). However, its widespread adoption has been hampered by issues such as technology costs, patient privacy concerns, and varying levels of digital literacy. These challenges highlight the need for substantial organizational changes in healthcare systems to fully leverage the benefits of telemedicine. In addition, the integration of environmental considerations into digital health technology assessments is crucial yet fraught with difficulties. Alami et al. (2023) identify that at the micro level, individual stakeholders' recognition of environmental issues influences technology assessment, while at the meso and macro levels, organizational culture, policies, and broader political and economic factors either support or hinder this integration. This highlights the need for systemic changes to incorporate environmental sustainability into digital health practices more effectively.

The experience in Indonesia, as explored by Shifa et al. (2024), illustrates the potential of digital health technologies to enhance healthcare efficiency, particularly in epidemic monitoring and remote medical services. However, issues related to infrastructure and equitable access remain significant, especially in remote areas. This points to a need for better infrastructure and broader access to ensure that digital health solutions benefit all populations equally.

The environmental impact of telemedicine, as discussed by Morcillo Serra et al. (2022), confirmed that digital health, specifically digital consultation and the download of digital vs paper reports, reduces the environmental impact of health care by reducing the number of journeys for a face-to-face visit and the number of the printing of medical reports. This shows substantial reductions in CO2 emissions due to decreased travel and paper use, emphasizing the role of digital

health in promoting sustainability. This environmental benefit reinforces the importance of continuing to develop and implement digital health solutions.

Despite these advancements, there is a notable gap in understanding the economic and managerial impacts of digital health technologies. Biancuzzi et al. (2023) found that while there is a growing interest in e-Health, most studies have focused on clinical aspects, underscoring the need for more research into the economic and managerial dimensions of digital health. The COVID-19 pandemic has accelerated the adoption of digital health tools, but there has been no significant shift in cost or performance evaluations, pointing to a need for further investigation into these areas. In a paper by Shaw and Glover (2024) there were 6 structural challenges to the effort to promote health equity through digital health, as follows: (1) the revenue-first incentives of technology corporations, (2) the influence of venture capital, (3) inequitable access to the internet and digital devices, (4) underinvestment in digital health literacy, (5) uncertainty about future reimbursement of digital health, and (6) justified mistrust of digital health. Building on these challenges, immediate and long-term directions for work to support meaningful change for digital equity are needed, including the managerial dimensions of digital health.

Finally, Stoumpos et al. (2023) highlight the global disparities in digital health adoption, noting that while some countries have made significant progress, others face substantial challenges. The development of secure communication systems and improved digital literacy among healthcare professionals are essential for addressing these challenges. Overall, the review suggests that while digital health technologies offer considerable benefits, addressing the associated challenges is crucial for optimizing their impact and achieving a more equitable, efficient, and sustainable healthcare system.

CONCLUSION

In conclusion, this literature review has examined the role of digital health transformation and management on sustainable development practices in the context of post-pandemic recovery, addressing the research problem by demonstrating the significant impact of digital health

technologies in overcoming traditional healthcare challenges. The findings underscore the potential of telemedicine, mobile health applications, artificial intelligence, and big data analytics to enhance healthcare accessibility and efficiency, particularly in low-resource settings. However, the review also identifies key challenges, including disparities in digital literacy, inadequate infrastructure, regulatory frameworks and concerns about privacy and costs, which must be addressed to fully realize the benefits of digital health innovations and require strategic leadership, cross-sector collaboration, and continuous evaluation to overcome.

To ensure the successful integration of these technologies, several practical recommendations are proposed. Governments and healthcare organizations should prioritize the development of robust policy frameworks and regulatory reforms to address privacy concerns, facilitate system interoperability, and establish reimbursement guidelines for telemedicine services. Investments in digital infrastructure, particularly in underserved areas, are essential to ensuring equitable access to these innovations. Additionally, improving digital literacy through workforce training and patient education initiatives is critical to bridging the digital divide. Furthermore, integrating environmental sustainability into the assessment of digital health technologies should be a priority, ensuring that telemedicine and other solutions contribute to Sustainable Development Goals (SDGs).

Future research should focus on the economic and managerial impacts of digital health technologies, as these areas remain underexplored. Studies should also address global disparities in the adoption of digital health solutions, with particular attention to developing secure communication systems and improving digital literacy in under-resourced settings. Longitudinal research on the long-term impact of digital health on patient outcomes, costs, and system efficiency will provide valuable insights for refining strategies and ensuring the sustainability of healthcare systems. Through these recommendations, the review aims to contribute to the ongoing efforts to optimize digital health transformation and inspire further investigation in this field.

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