A Systematic Review and Bibliometric Analysis of Emerging Technologies for Sustainable Healthcare Management Policies

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Abstract

This research seeks to examine effective strategies that promote the sustainability of medical organizations, given that the healthcare industry and its operations impact several aspects of social life, financial markets, and governmental efficiency, underscoring this topic's significance. The present research employed the systematic review technique, sourcing data from 1032 publications that appeared in the two most referenced databases: Scopus and Web of Science. The study yielded several efficient procedures to enhance the sustainability of medical corporations: enhancements in leadership and administration procedures, selection of executives, clinician involvement in administration, advancement of company behavior and leadership style, advancement of virtual health interaction, ecological supply chain administration, logical resource utilization, and managing waste.

Keywords: Emerging Technologies; Healthcare; Sustainability; Bibliometric Analysis.

I. INTRODUCTION

The imperative to address the adverse effects of global challenges, including aging populations, warming temperatures, ecological degradation, prejudice, and inequality, alongside adherence to the 2030 Schedule for Sustainable Growth ratified by all United Nations Participants States in 2015, has intensified pressure on all economic stakeholders, particularly within the medical industry. The operations of healthcare institutions are crucial as they directly influence the attainment of the 17 Sustainable Development Goals (SDGs), particularly regarding healthy living, gender equality, sanitation and hygiene, and clean and inexpensive energy (Pizzi et al., 2020).

The progression of Information Technology (IT) has led to substantial enhancements in medical care, especially in health surveillance via the Internet. The fundamental objective of utilizing physical sensor networks is to emphasize avoiding illnesses and the early detection of high-risk health conditions. Technological sophisticated and intricate devices (including intelligent wireless and wearing detectors) have significantly increased the swift tracking and handling of patients' conditions through immediate access and ongoing evaluation of essential health indicators.

The ability of these intelligent gadgets to store and transmit data is essential in several aspects of medical care, such as teleconferences. Smartwatches are predominantly employed to monitor and assess individuals' health issues and conditions, along with several other health-related functions. The vital health signals indicate the individual's physiological condition, organ function, and disease development. Evaluating these markers substantially impacts illness avoidance, diagnosis, therapy, and nursing treatment. This health information is a valuable reference for effective and high-quality healthcare if evaluated precisely and swiftly. Many intelligent gadgets, Internet of Things (IoT) methods, and Artificial Intelligence (AI) platforms have been engineered to improve the timely and ongoing evaluation of patients' medical histories and relevant healthcare components (Kakhi et al., 2022).

Presently, organizational sustainability is seen as an industrial approach that includes the following aspects: ecological, social, and financial. Adopting eco-friendly technology, minimizing waste and detrimental emissions, recycling and reusing resources, and enhancing societal awareness of environmental concerns are essential elements of sustainable development. Social viability is defined by safeguarding human rights, combating prejudice and inequitable mindsets, ensuring equitable access to public services and products, and initiatives designed to cultivate social capital and systems in the broader society. A company's financial viability is viewed as a means to concurrently uphold elevated revenue and quality of life through implementing innovative green methods, minimizing energy consumption and waste, and combating impoverishment and other fiscal difficulties within the local region.

II. BACKGROUND

This section presents and discusses relevant studies and literature on applying sensors, IoT, AI, and Blockchain in Healthcare Management Systems (HMS) (Villarreal et al., 2023). This evaluation is essential to underscore the deficiencies of comprehensive assessment and delineate the advantages and disadvantages of relevant taxonomically and conceptually relevant approaches.

Dwivedi et al., examined using Internet-of-Medical-Things (IoMT), AI, and edge computing for healthcare provision in pervasive settings (Dwivedi et al., 2022). They proposed that the technology above aids in effectively monitoring and controlling medical facilities. Reports indicate that the increase in individuals and illnesses has made it challenging for medical personnel to sufficiently address people with comparable medical concerns. They proposed that implementing developing technology, such as AI approaches, can address these escalating difficulties. The research examined smart HMS and various types of sensor elements employed inside their individual IoT architecture. They classified and examined relevant research according to their utilization of device-based and device-free methodologies. They determined that multiple combinations of these strategies can be innovatively utilized to enhance existing HMS. The study examined the implementation and challenges of Big Data Analytics (BDA) as a manifestation of artificial intelligence techniques. Their analysis indicated that BDA plays a crucial role in the technologies offered by HMS. Kumar et al. examined the feasibility and implementation of Health Internet of Things (H-IoT) devices in smart cities (Kumar et al., 2023). They evaluated HMS-affiliated technology to provide a perspective on health surveillance using diverse wearing sensors.

The research examined contemporary communication paradigms, notably wireless networks, highlighting their significance and relevance with new technologies like AI and Blockchain to advance HMS. A comparative study of multiple architectural options was undertaken, including their advantages, disadvantages, and quality-of-service requirements. The research comprehensively assessed the application of AI approaches in HMS. The merits and weaknesses of existing methods and other research challenges were examined. The research established a unique taxonomy within the IoT-ML framework to assist scientists in future investigations into HMS (Presciuttini et al., 2024). The research examined the current developments in intelligent HMS. A comprehensive examination of IoT, AI, cloud computing, and blockchain as new developments in intelligent medical care is provided. The research examined contemporary uses of wearable sensors utilizing artificial intelligence algorithms.

The research investigated improvements in IoT-based medical technology and analyzed innovative methodologies for IoT-based HMS. IoT security and privacy facets were evaluated, including security standards, threat designs, and attack classifications. An advanced cooperative security model aimed at mitigating security risks was provided, along with insights on using fresh innovations like big data, ubiquitous knowledge, and wearables within the medical sector context, highlighting potential pathways for future study on IoT-based health causation.

The research provided a comprehensive review of the foundations of Ambient Assisted Living (AAL) studies, focusing on technologies and approaches for cognitive support in home environments (Panico et al., 2020). They emphasized effective instances and practical solutions. The research comprehensively analyzed cutting-edge IT products aimed at enhancing medical. They proposed practical insights about the impact of IT advancements on healthcare operations. The study suggested an agent-based design that enables ad-hoc system configurations, emphasizing strategies for attaining real-time intelligent monitoring in Smart Health environments through a privacy-centric communication method to safeguard individual identities while exchanging sensory data.

A unique aspect is that, unlike additional survey works, the research compiled study materials according to the proposed taxonomy and sub-classifications. The research structured all the survey papers accordingly, showcasing several types of personal and ambient sensors and their applications in HMS (Mamdiwar et al., 2021). A comprehensive investigation was performed to identify various types of sensors employed in HIMS under several conditions, and the observed data are compiled and presented. Sensors and developing boards are examined as components of IoT technology. The research notably elucidates the implementation of AI and Blockchain methods inside the HMS. This format and classification of the AI and Blockchain parts are unprecedented compared to current survey reports. These substantial improvements render this study comprehensive and equitable compared to previous polls.

III. METHODS

The research employed the technique of systematic review to fulfill the paper's objective, addressing a gap in the literature by identifying, analyzing, and describing prior findings on efficient processes for transitioning to sustainable management of medical facilities, ultimately contributing to the achievement of the SDG. Moreover, recent studies have proposed examining

businesses' financial, social, and environmental behaviors contributing to enhanced sustainability.

The review aimed to recognize, evaluate, and sum up prior findings in the current research while proposing effective practices for medical organizations to ensure their continued existence and the future achievement of the SDGs.

Stage 1: Selection of benchmarks includes published research from diverse publications, English-language papers, and peer-reviewed journal articles.

Stage 2. Secondary information was gathered from publications inside the two most referenced records: Scopus and Web of Science. The literature search utilized the keywords "sustainable development" and "health care," with a temporal restriction from 2020 to 2024, to identify the most recent and pertinent strategies adopted by medical institutions in light of contemporary social and economic conditions. As a result, 1032 papers have been identified.

Stage 3 involved doing a manual content review of all identified publications by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to mitigate uncertainty. Figure 1 illustrates a PRISMA flow model.

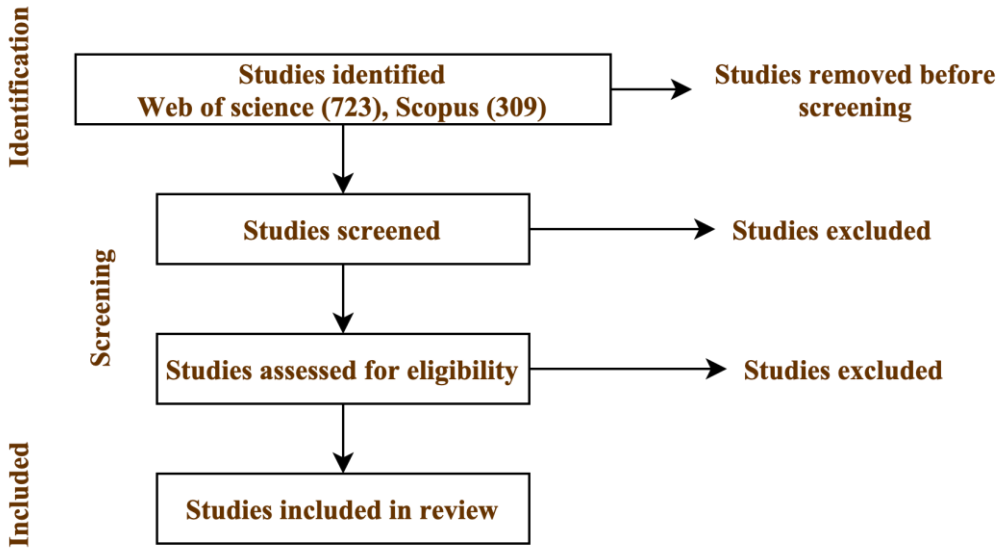


Figure 1: PRISMA Workflow

The title screening facilitated the elimination of duplicate articles, and content assessment was conducted to omit papers needing more vital details on the strategies adopted by hospitals and their effects on sustainability levels. Studies were removed due to their need for empirical evidence demonstrating the efficacy of company actions. As a result, 67 publications were recognized as databases and incorporated into the systematic examination. The present study encompasses the most recent research findings from diverse authors worldwide.

Stage 4. The prevalent effective and practical techniques of medical facilities striving for sustainability were identified by studying additional information from the selected publications.

Stage 5. The data acquired, prior discoveries were analyzed and verified, and practical comments and proposals for further research were offered.

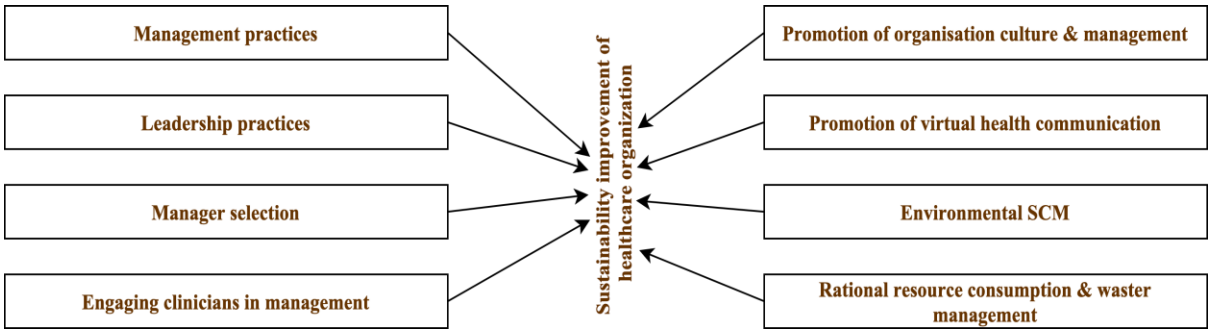


Figure 2: Sustainability Healthcare Organizations

Figure 2 encapsulates the several strategies proposed and evaluated in prior research. The subsequent practical approaches are aimed at attaining organizational sustainability: Enhancements in management strategies, fostering leadership, particularly "involved with others" administration; management hiring procedures that consider managerial personal attributes; promoting and facilitating of clinicians' involvement in the leadership, enhancement, and alteration of organizational culture and leadership style; expanding the utilization of virtual ways of communicating in the medical field, as it facilitates equitable interaction between healthcare providers and physicians while concurrently reducing costs, intake, and environmentally friendly impact; advocating for an environmentally sustainable supply chain, which reduces the overall degree of environmental decline; promoting judicious resource usage, which enhances the effectiveness of accessible natural resources through promoting reuse and recycling, and a transition towards durable products instead of disposable items, thereby endorsing strategies for minimizing the production of waste by medical facilities.

IV. DISCUSSIONS

4.1 Enhancements in Management Techniques

The existing scientific literature on efficient leadership structures in the healthcare industry identifies many critical aspects that directly or indirectly influence the long-term viability of a company. It has been demonstrated that management expenditure correlates positively and directly with the efficiency level of medical companies; in particular, heightened expenditure lowers patient waiting times. Research has shown that medical efficiency is enhanced with increased management expenses. Enhancements in management techniques correlate favorably with mortality rates and total financial success, quantified as revenue per bed. Simultaneously, it has been demonstrated that implementing agile leadership techniques enhances the general effectiveness of healthcare organizations by improving production and quality.

Considering the particularities of medical facilities, physicians play a pivotal role in management procedures since they identify the demands and associated expenses of the business. Physicians should participate on the board and engage in all management-related activities, including preparing a budget, arranging, hiring, and monitoring.

From the point of view of sustainability efficiency, adherence to green and ecologically focused policies, the adoption of cutting-edge information methods, the development and implementation of green strategies and procedures, employee knowledge of ecological problems,

and the allocation of assets towards aesthetically extending practices are essential prerequisites for a firm's general viability.

4.2 Leadership Methodologies

Research on leadership has similarly established a positive correlation with the efficiency of healthcare organizations. In this context, it is essential to note that leadership differs from managerial methods, which encompass scheduling, budgeting, organizing, hiring, and regulating. Leadership roles and procedures focus on problem-solving, guidance, and staff motivation. Leaders can apply many ways to influence and enhance staff performance and conduct, thus increasing the organization's efficiency and sustainability. Management has been demonstrated to correlate favorably with people's happiness, preservation, and productivity.

Notably, a defining trait of an administrator is a level of leadership, or "involvement with other people," which serves as a crucial predictor of total organizational effectiveness. Effective leadership via proficient problem-solving and guidance, dissemination of knowledge, and exemplifying behaviors pertinent to social and ecological issues favorably influences a company's sustainability levels.

4.3 Involving Clinicians in Management

Researching practices that promote sustainable growth reveals that managerial specializations significantly influence performance at work; specifically, a physician or managerial position is more adept at structuring processes to enhance the medical efficacy of a company.

Even managers needing more medical education and a history of effective management enhance a firm's general effectiveness and financial success. Moreover, research has demonstrated that increased physician participation in managerial procedures correlates with improved medical and general performance. Physician involvement is essential for an effective and sustainable medical company. Physicians' participation in administrative processes is realized through several means: as a constructive and proactive contribution, fostering and promoting excellent care, and engaging in innovations.

Moreover, physician involvement guarantees enhanced sustainability via the following beneficial results: decreased patient death rates, fewer adverse incidents, enhanced financial efficiency and standard of care, enhanced collaborative culture, superior relationships with others, fulfillment in work, and increased trust.

4.4 Advancement of Organizational Culture and Management Approach

Many studies have been undertaken to identify the organizational environment and leadership style that would guarantee elevated performance and, therefore, the longevity of a business. It has been demonstrated that highly effective health companies choose a transactional managerial strategy instead of a spectacular one, with management procedures encompassing strategic planning, spending, and company planning. In addition to these distinctions, medical facilities exhibiting more sustainability possess congruent organizational principles and objectives, active upper management participation, extensive staff engagement, enhanced interaction and collaboration among personnel, and problem-solving and learning methodologies.

4.5 Ecological Supply Chain Administration

In this setting, it is essential to note that supply chain management is examined from two perspectives: inside and outside. The outside chain encompasses manufacturers, purchasing categories, suppliers, and customers, while the internal chain comprises supply and inventory control, restocking, and usage operations. Ecological supply chain management endeavors to minimize transportation expenses and detrimental emissions, promote eco-conscious suppliers, and facilitate a transition towards recyclable and eco-friendly products and the reduction of packaging, thereby ensuring enhanced financial outcomes and long-term sustainability.

V. UNRESOLVED RESEARCH ISSUES IN INNOVATIVE HEALTHCARE DELIVERY TECHNOLOGIES

Academics have undertaken numerous initiatives regarding IoT-based solutions for medical fields employing AI; certain limitations persist, as delineated in the prominent issues. With the advancement of IoT and next-generation Machine Learning (ML), including Deep Learning (DL) and Reinforcement Learning (RL), various avenues for study will emerge. This study has identified research difficulties and open subjects covered in the subsequent subsections.

5.1 Data Acquisition

Meticulously maintained datasets are essential for the efficacy of AI-driven Health Management Systems. Numerous initiatives have been undertaken to train Supervised Machine Learning algorithms with current information. Most of the study employed datasets from publicly available sources from other persons or institutions. These databases frequently contain inadvertent bias, insufficient variance, and missing values. Collecting datasets is an essential endeavor, especially in the healthcare sector. Moreover, modifications to environmental control variables affect the dataset's characteristics and effectiveness. The data included in HMS can exhibit incompatibility, presenting an added challenge.

5.2 Handling Data Streams

Data Stream Mining is a method for collecting essential details from constant and fast data streams. The contemporary healthcare industry utilizes real-time elements to collect quick and helpful physiological data by implementing remote HMS. This concept pertains to the management of continuous and extensive data flows. Information transmitted over the IoT architecture from sensors exhibits significant speed, variety, and integrity. The challenge is collecting and analyzing this data flow, addressing issues such as idea drift, model rehabilitation, imbalanced class labeling, high dimensions, and adaptable choice of models. This is an emerging subject that warrants more exploration within the framework of IoT-based HMS.

5.3 Security

Health-related information is often obtained from patients (actively or passively), transferred, and kept in databases, essential for proper treatment or care. It is necessary to safeguard the patient's confidential information. Security during data transfer, processing, collection, and storage pertains to safeguarding data from unwanted access or alteration. Additionally, many measures must be implemented at the sensor-adjacent level to protect user information. An AI-based HMS is a superior option to ensure data security.

Three essential security attributes must be ensured:

Privacy: Encryption is the appropriate technique for safeguarding information privacy, requiring the disseminating of a shared key via a WSN transmission path.

- Integrity: An assailant must not be able to alter the health-relevant information stored within a device. To guarantee the precision and uniformity of this data, the necessary procedures must be implemented.
- Availability: The medical data must be promptly accessible upon request by an authorized individual. Patient knowledge is essential and must always be freely available over the network.

5.4 Privacy and Ethics

Privacy pertains to the management of patient information by the issuing agency. The document must delineate the location of records and the individuals authorized to access an individual's health data. Physicians, nurses, and caretakers can view and manage this data. This sensitive material must be disseminated to others in certain circumstances to secure appropriate treatment or care. Moreover, individuals hesitate to disclose extensive personal information (such as an early pregnancy) to those outside their family. This data should remain confidential. Moreover, as the sensor layer is nearest to the user, it needs enhanced protection against external dangers.

Patient private information is stored in a recording device during remote surveillance. Any unauthorized access to such personal information must be safeguarded. A trade-off must be acknowledged between preserving privacy and providing personalized service. The increase in health-related information will intensify ethical issues regarding the decision-making skills of AI-HMS. The repeatability of AI models is frequently overstated, and the methodologies exhibit a need for more sympathy, which poses a significant issue in the medical field.

5.5 Explainable AI

Recent ML research has shown a remarkable increase in supervised ML employing multi-modal deep learning. Decisions in the medical field are frequently grounded in analogous past data. This has created a new opportunity in AI and necessitates more study in the healthcare industry. Moreover, ML models like Generative Adversarial Networks (GANs) are frequently utilized for dataset enhancement, enhancing the overall efficacy of machine learning algorithms. To our understanding, GANs are underused in this domain. Recent applications of Deep RL methodologies have emerged in agent-based modeling within the medical field. A more sophisticated version of the HMS is necessary before the widespread use of RL-based methods.

5.6 Underdeveloped Countries

Literature indicates that investigators frequently base their beliefs on the infrastructure of the research region or locality. The AI models that have been successfully reported predominantly originate from industrialized countries. Conversely, only some practical initiatives have been implemented in the undeveloped areas. The deficiency of medical facilities is the principal obstacle, akin to the absence of communications networks (such as the Internet), restricted data access, elevated equipment costs, and stringent rules that hinder the healthcare industry.

VI. CONCLUSION

The findings of this systematic research are relevant to several domains, including theoretical, managerial, and policy-making contexts. Theoretical applications are advantageous for researchers as they represent the most effective practices that guarantee long-term viability for an organization. They can be utilized for additional studies to evaluate the effect of each proposed practice, examine the efficacy of practice combinations, compare the impact of practices across various nations, and discern the socioeconomic constraints associated with these procedures, thereby enhancing the existing body of literature. The results of this investigation might be utilized for theoretical advancement and evaluation. The results can be used by educators in business classes or for offering business counsel to healthcare companies.

Managerial execution encompasses the following: practices designed to minimize natural resource consumption; a transition towards reusing and the utilization of durable products; the promotion of environmentally sustainable methods and procedures; the encouragement of online interaction among staff as well as between medical professionals and clients; the integration of electronic records systems and e-commerce; the fostering leadership skills and the cultivation of sustainable employee behavior alongside a corresponding framework of knowledge, customs, society, morality, and way of life; the execution to ecological supply chain tenets the involvement of doctors in executives; and the preferential selection of leaders with relevant expertise and prior experience in the medical industry.

The public sector must proactively integrate outcomes into policy-making by incentivizing healthcare providers to adopt environmentally sustainable technologies and practices through benefits or tax reductions. Concurrently, the public sector must regulate the accuracy of medical data disseminated, as misinformation can adversely impact public health. The government should enhance understanding of global financial, environmental, and social challenges among adults and kids, as human participation in addressing these issues is influenced by culture, conventions, opinions, morality, and prevailing behaviors.

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