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Emerging Technologies in Healthcare Organizations for Quality Patient Care and Safety, Improved Operations, and Technological Sustainability: A Qualitative Study Based on the Design Thinking Approach

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Abstract

Healthcare facilities also consume enormous amounts of energy, generate massive quantities of waste, which contribute to the carbon footprint. The new energy-efficient technologies can enable sustainable facilities, which can reduce bio-medical waste, conserve water and energy, and thus facilitate to creation of a safe environment for patients, hospital staff, and visitors. To explore and understand the challenges of sustainable and agile practices in healthcare operations and their impact on the three pillars of sustainability. To examine the measures of sustainable healthcare and their impact on quality patient care and patient safety. This study employs a case study approach and qualitative research, systematically collecting and analysing thematic primary information from open-ended and semi-structured discussions with 50 healthcare stakeholders, based on research questions related to sustainability dimensions, processes, and practices. Emerging technologies like robotic surgery are enhancing patient safety, surgical precision, and clinical outcomes in leading Indian hospitals. As healthcare shifts towards value-based models, these innovations improve care quality, operational efficiency and economic sustainability, addressing rising chronic disease burdens and transforming traditional service delivery in Indian healthcare organizations. All these efforts can lead to an agile approach in hospitals that can effectively adapt technologies and innovation in clinical protocol, workflows, patient experience, and digital health technology with the objective of improving care. These can lead to an operation that is profitable and viable for the organization, and also affordable to patients and the social community at large.

Keywords: Sustainability, technology, healthcare, patient safety, quality standards, design thinking

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1. Introduction

The issues of sustainability, technology, and agile operations in healthcare organizations are a multi-disciplinary domain dependent upon each other; they encompass the areas of medical science, operations management, and sustainability itself. The United Nations' (UN's) Sustainable Development Goals (SDGs) framework has reoriented policies of development, priorities of governments, business, and citizen responsibilities, and for measuring benchmarks for development progress worldwide. Sustainability has three components/ dimensions: environmental sustainability, that is, conservation of the environment, natural resources, and climate while utilizing the environmental resources; social responsibility in the form of social welfare activities; and economic sustainability, which is based on the long-term economic growth without depleting resources and damaging the environment. The social pillar of sustainability addresses the well-being of individuals or on a community level, by promoting equity in healthcare services, access, and affordability to healthcare, and improving health outcomes. In this paper, we introduce a fourth component/ dimension of sustainability in healthcare organizations, that is, patient-centric continuous improvement sustainability, based on a design thinking approach and technology.

The current trends of developments in economic and social arenas are putting pressure upon natural resources and may jeopardize the continued health and prosperity of human and other living creatures' populations (Eason and Frederickson, 2012). The healthcare industry's involvement in using and degrading the natural environment has become increasingly clear in recent years. Hensher and McGain (2020) mentioned that healthcare's global carbon footprint is 4.4 percent of the world's total greenhouse gas emissions, as per an estimate in 2019, and health expenditure accounts for some 10 percent of global economic output (Karliner et al., 2020). Healthcare and sustainability are interdependent and related. The quality of our environment affects public health of the local population, patient care and recovery in hospitals, patient safety given hospital-acquired infections, health safety of visitors and relatives in hospitals; it also impacts well-being, efficiency, agility and productivity of all healthcare workers including physicians, nurses, paramedics and supporting staff working in healthcare operations. Its impact on the community is most prominent in the case of the rural population and underprivileged subsets of women (Afzal & Das 2023; Afzal et al., 2025).

The Indian healthcare industry's size is estimated to have reached US$ 372 million in 2022 and to reach US$ 516 million by 2023 (IBEF report, 2022), driven by rising incomes, better health awareness, lifestyle diseases, and increased access to health insurance (IBEF report, 2021. The large healthcare sector is a key driver for economic growth in India in terms of both revenue and employment. Therefore, it is time for systemic, structural, and business process re-engineering. In the healthcare ecosystem, innovative and sustainable models of care delivery are being developed with the help of emerging technologies. Besides environment conservation, we also require efficient resource management, cost-effectiveness, and continuous improvement of healthcare services (Marimuthu and Pauloae, 2016). Nowadays, environmental change and climate change are gaining the attention of researchers globally, as it is impacting various aspects

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of human life, which is most common in underdeveloped and developing countries (Afzal et al., 2024). However, we need to identify the actions to be taken at different levels and processes and leverage technology for the transformation of traditional healthcare to sustainable and agile healthcare (Mehra and Sharma, 2021). The primary objective of the present article is to explore and understand the challenges of sustainable and agile practices in healthcare operations and their impact on three pillars of sustainability. Furthermore, to examine the measures of sustainable healthcare and their impact on quality patient care and patient safety. This paper also attempts to identify the areas of leveraging technology applications in these practices for value addition and to solve the challenges.

2. Method

2.1 Design

The case study approach and qualitative research are used, which involves systematically collecting and recording the contents and thematic primary information analysis from various open-ended/ semi-structured interactions and discussions based around research questions, dimensions, and processes/ practices of sustainability with the various stakeholders of the healthcare organizations. We also observed the different green infrastructural facilities, patient care programs, and technology used by multi-specialty hospitals and other healthcare organizations to manage their systems.

The research study is exploratory and descriptive because it explores, observes, and notes the existence of the practices and activities and their perceptions/ opinions for the different elements (dimensions) of sustainability of different stakeholders, including consultant doctors, resident doctors, administrators, senior managers, strategy officers, nurses, paramedics, housekeeping staff, floor coordinators, managerial executives and staff, pharmacists, stores, research staff, laboratory and diagnostic specialists/ staff, and other supporting services staff. The observations and perceptions of patients were also recorded. These practices were being analyzed concerning the interlink between medical science and the operating environment and sustainable practices for better diagnosing of the disease with the help of diagnostic technology equipment, medical devices and laboratory tests to prescribe appropriate therapeutic and medical interventions to restore the normalcy and quicker recovery of patients for a better quality of life. The activities of the hospitals also involved guiding the patients to adhere to medications, lifestyle and dietary modification, and exercise for long-term sustainability of good health. The research data obtained from clinical practices, therapeutic protocols, and other field information are analyzed by the hospitals' expert committee for improving the quality of health outcomes of the suffering patients by following a patient-centric approach and not merely treating the disease (Rao, 2019). This helped to gather secondary data and information that describes healthcare programs.

The respondents for open-ended interactions and discussion numbered about 50, belonged to various categories of stakeholders in three multi-specialty hospitals in Delhi-NCR. These included consultant 5 doctors, 5 administrators, 5 senior managers, 5 strategy officers, 16

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paramedics, 4 housekeeping staff, 2 floor coordinators, 5 managerial executives and 3 other supporting services staff.
It also included a few relevant sample cases, and writings by researchers and observers regarding such programs were considered for Indian hospitals and hospitals abroad that are available in published sources.

2.2 Data collection

Data collection was conducted from June 2023 to September 2023. For the collection of secondary data, a systematic and comprehensive quality search of review articles, research papers, hospital websites, press releases, and scientific journals was conducted.

2.3 Surveyed items

Utility of technology towards four items were analysed, namely (i) environmental sustainability, (ii) health outcomes and social sustainability, (iii) operational and economic sustainability, (iv) continuous improvement sustainability through design thinking approach.

2.4 Analyses

Thematic analysis of qualitative data was done using NVivo software (version 15).

3. Results

Pollution control technologies monitor and reduce harmful emissions into land, air, and water. Natural resource conservation efforts utilize wastewater recycling, rainwater harvesting, and water-wise practices. Energy-efficient buildings incorporate LED lighting, inverter-based air conditioning, and consolidated lift systems to minimize electricity waste. Many healthcare facilities have also transitioned to electric/battery-run vehicles for internal transport to lower carbon emissions. Additionally, green architectural design emphasizes natural light and ventilation to cut artificial energy use. Sustainable purchasing promotes an environmental culture by ensuring non-toxic, properly labelled materials and efficient use of consumables. These technological interventions boost operational efficiency and align healthcare with climate and sustainability goals.

Another crucial benefit is cost reduction, achieved by optimizing the use of material and human resources and minimizing waste, thereby making healthcare more affordable. According to the National Accreditation Board for Hospitals and Healthcare Providers, this includes monitoring clinical quality, patient safety, and managerial efficiency indicators. Accessibility to healthcare is also enhanced by streamlining the admission process, providing transportation options, and expanding telemedicine services for patients in remote areas. Mobile apps further simplify appointment scheduling for outpatients, inpatients, and emergency cases.

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Technology ensures round-the-clock availability of healthcare services across outpatient and inpatient, and emergency departments, while also supporting healthcare insurance schemes. Safe medical practices are implemented through modern sterilization techniques and infection control protocols, which reduce hospital-acquired infections and antibiotic misuse, ultimately enhancing patient safety and public health, patient comfort is prioritized by ensuring timely medical interventions, hygienic food, clean accommodation, and other supportive services, alongside maintaining a healthy work environment for staff.

Healthcare organizations also contribute to local sustainability by hiring qualified personnel from the local community, which reduces commuting time, sustains the local economy and enables quicker emergency response. Additionally, training programs for local individuals help retain staff and maintain operational consistency. Overall, the integration of technology into healthcare does not support better patient outcomes and employee wellbeing but also fosters long-term sustainability by promoting disease prevention, guiding healthier lifestyles, and ensuring continuous responsive healthcare delivery for the entire community.

Implementation of value to economic sustainability in the healthcare organization was one of the core components required, and to make this applicable, a number of processes and practices can be used, and some of them are being used in healthcare settings (Mehra and Sharma, 2021). Designing a green hospital aligns with a green economy and involves adopting low-carbon, resource-efficient solutions that create a healing environment through natural light, fresh air, and proper ventilation. This is achieved by integrating green architecture technology as recommended by the National Accreditation Board of Hospitals (NABH) rather than any relying on traditional technologies. Such an approach not only enhances patient well-being but also reduces operational costs and overall expenses for both the hospital and patients. Furthermore, encouraging research and innovation in therapeutic protocols can lead to significant improvements in clinical, nursing, and support service practices. This advancement may contribute to better patient outcomes while simultaneously lowering healthcare costs and operational expenditure. Implementing green growth strategies, such as optimizing material use, promoting efficient practices among hospital personnel, and adopting disaster-resilient architectural designs, can further reduce costs and enhance profitability. These savings can be reinvested in emerging technologies and advanced medical devices that support precise diagnosis and treatment, making healthcare more affordable and accessible. Additionally, promoting indigenous production of advanced medical devices is crucial, especially since only a few consumables are currently manufactured domestically. Government regulations now offer incentives to encourage the development of portable, durable devices suited for rural areas. Such as solar-powered ECG and portable X-ray machines. The COVID-19 pandemic accelerated the adoption of health monitoring tools for chronic illness at home, including oximeter digital thermometers, BP monitors, and glucose meters, many of which are now produced in India. These devices have empowered physicians to offer consistent care and advice, ultimately enhancing disease prevention and management. The expansion of telemedicine during the further

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optimized to use hospital infrastructure, reserving inpatient care for critical cases and contributing to economic to the economic sustainability of health care providers.
The amalgamation of technology with a design thinking framework offers a strategic pathway to achieving continuous improvement and sustainability in healthcare delivery (Figure 1). Design thinking is characterized it iterative stages. Empathizing and problem identification, defining the problem. Ideating through brainstorming, prototyping, and piloting. Followed by holistic implementation enables healthcare organizations to develop patient-centric innovations that are both practical and scalable. When combined with digital technologies, the approach has demonstrated significant potential in enhancing healthcare outcomes and service efficiency (Rao, 2019; Yende, 2018), (some highlights from qualitative interactions and case examples).

Empirical insights derived from qualitative interactions and case examples illustrate how specific processes are currently being implemented to add value to patient-centred care. One such practice involves promoting advanced appointment scheduling through digital platforms such as websites and mobile applications, thereby improving patient flow and reducing waiting time for unscheduled consultations. Furthermore, the effective utilization of appointment slots is facilitated by the availability of patient history and medical records within the Hospital Management Information System (HMIS), enabling clinicians to dedicate more time to patient interaction, continuity of care across different providers, and integration of data from monitoring devices, particularly for patients with chronic conditions.

In addition, optimizing the waiting period in OPD through engagement with health counsellors and dieticians allows patients to receive tailored advice on recovery, disease prevention, nutrition, and the use of hospital applications for follow-up queries. This not only mitigates patient anxiety but also enhances the perceived quality of care. A further critical advancement is the centralization and interoperability of patient records. Centralised case notes accessible across departments and healthcare institutions ensure continuity of care, while also empowering patients to retrieve their medical information from remote locations using personal devices.

4. Discussion

Green or sustainable design of healthcare facilities optimizes the environmental, social, and economic performance of healthcare. The environmental carbon footprint of greenhouse gas (GHG) generated during the life cycle of healthcare could be minimized. These also result in significant cost savings for healthcare organizations. The biomedical waste can be managed efficiently utilizing the method of incineration and autoclaving, etc, that ensures healthcare hygiene and safety of patients, employees, and local communities (WHO, 2005). This also controls pollution through the reduction of harmful emissions, such as chemicals and gases, to land, water, and air. In addition to social and economic benefits, sustainable procurement initiatives help in reducing specific environmental risks by not buying items like toxic chemicals. Many of the multi-specialty hospitals in Delhi-NCR, including Max, Apollo, Holy Family, etc., follow the above measures and processes (CEH, 2019).

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The researchers and scientists are tremendously optimistic that technology can improve health outcomes and increase overall life expectancy. One such technology is Artificial Intelligence (AI), which includes algorithms, machine learning, and pattern recognition; AI holds immense potential to transform the healthcare sector. Integration of AI in healthcare services can help to detect skin diseases, pneumonia, breast cancer, and other diseases with the help of Image analysis algorithms (Teenspire, 2021). Speech recognition software can potentially cut down on the administrative load of doctors to a great extent by cutting down on the time taken for medical records. Augmented reality is making it possible to remotely monitor clinical procedures, for example, wound care, thus making expert advice more accessible in real time. Robotic systems are also being used more and more to conduct routine as well as advanced surgical procedures. Empirical research indicates that in some contexts, robotic surgery displays better outcomes compared to conventional methods, specifically in lowering postoperative infections and achieving more accuracy when performing activities like intestinal suturing. These cutting-edge technologies have been implemented in the healthcare sector across major hospitals in the United States and Europe, and major healthcare institutions in India like Max Healthcare and Apollo Hospitals. (Taeenspire, 2021). There has been a rise in life expectancy and an increase in chronic/lifestyle diseases in India. The existing models of healthcare delivery cannot sustain themselves in coping with this transition from volume-based care (diagnosing and treating acute cases) to value-based care (preventing and managing chronic cases) (Rao, 2019).Emerging advances in digital health technologies have led to a more educated population of patients, and hence, higher expectations of accessible and uninterrupted healthcare services. Equipped with a wider set of options and more exposure to medical knowledge, patients now expect more active engagement in their care process and also prefer self-managing recovery processes.

In order to understand the patient population with a patient-centric/ human-centric problem-solving/ design thinking approach, it will be important to decide on the appropriateness of specific technology use (Yende, 2018). The design thinking approach allows hospitals to empathize with the patients and their families to drive a measurable return on their investment of time, money, and anxiety when they come for healthcare services under certain stressful conditions, unlike other service situations. The hospitals should continually improve via new services to keep the patients and their referrals engaged and build lasting values (Rao, 2019). Many hospitals abroad, like the Mayo Clinic, Stanford Hospital, and Rotterdam Eye Hospital, are getting the benefits of having invested in design thinking (Rao, 2019). It is being implemented in some bigger multispecialty hospitals in India too, like Max, Apollo hospitals in Delhi-NCR, etc. For example, with emerging technology usage, there could be home-based telemedicine, advanced healthcare technologies such as minimal to non-invasive surgeries with online monitoring and alarm systems, and Internet of Things (IOT) technologies (Celdran et al., 2018). They address the issues of healthcare access, affordability, quality, patient safety, and patient satisfaction.

The continuous improvement through technology and the design thinking approach can enhance the quality of services and trust in the services (Smith and Harper, 2015; Afzal & Zaini, 2015). It

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is critically important for a patient as a consumer of healthcare services. Another aspect of these technologies is that they have the potential to be synchronized with other information systems, which will develop a synergy when used in combination with preexisting information systems, such as Hospital Information Systems (HIS). This amalgamation will play a pivotal role in decision-making not only by the hospital administration but also by the policymakers (Sahota et al., 2024).

5. Conclusion

The examination in this research delved into the key elements and obstacles associated with incorporating sustainable and agile methods in the healthcare sector, evaluating their effects on the ecological, societal, and financial aspects of sustainability. Failure to adhere to sustainable development principles results in environmental deterioration and heightened human distress, with the healthcare field shouldering a disproportionate share of this burden. As a result, healthcare decision-makers, guided by governmental and regulatory directives, are placing growing emphasis on sustainability. The document outlined a range of steps and techniques to tackle these hurdles, highlighting the potential of technology to significantly enhance value across all sustainability facets. By making use of cutting-edge technologies and sophisticated equipment within financial limitations, healthcare activities can become more effective, flexible, and financially feasible. This adaptation is crucial within the intricate, interrelated landscape of healthcare institutions. Social sustainability holds utmost importance, covering favorable health results, patient welfare, and recuperation. It also encompasses employee contentment and dedication, acknowledging that a well-supported workforce provides exceptional patient service. We explored how technology can boost health results, elevate quality of life, and extend life expectancy while averting future ailments. An important finding of this study is the emphasis on ongoing enhancement in healthcare sustainability through a design-oriented approach and technology. Given the human-centered essence of healthcare, a human-centered issue-solving methodology is essential for continual progress in patient-focused operations. This strategy ultimately propels exceptional patient service and safety, profoundly influencing all other sustainability dimensions.

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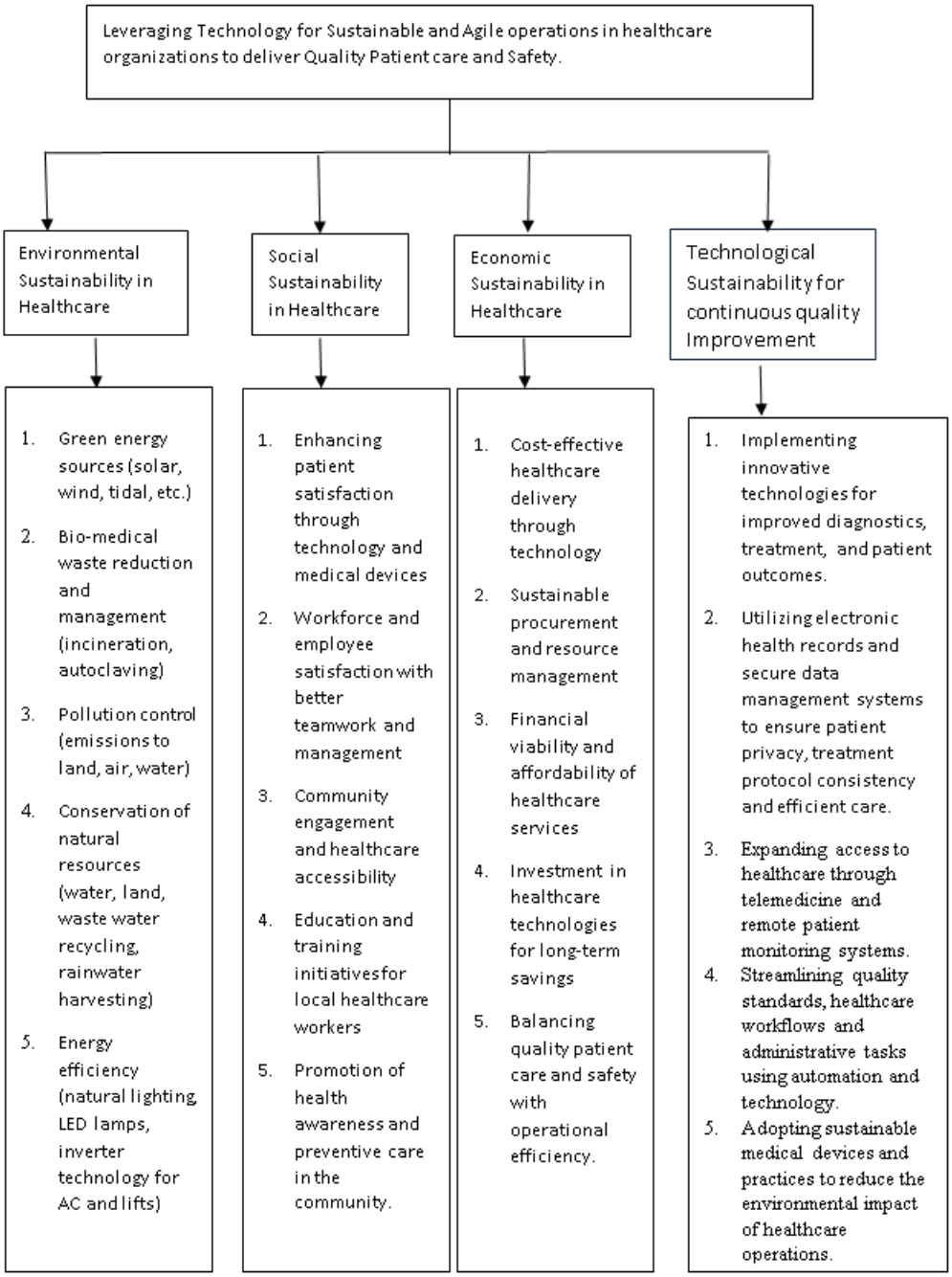

Figure 1. Conceptual framework of a technology-based model of sustainable healthcare operations.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author's contributions

All authors contributed equally in conducting this study and preparation of manuscript.

Source of funding

None.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Limitations

It's important to acknowledge that our study faced some real-world constraints. With just around 50 participants from three specific hospitals in the Delhi-NCR area, the insights we gained, while valuable, might not fully represent the broader healthcare landscape. Because we relied on understanding people's experiences and perspectives, there's also a natural element of individual interpretation in our analysis. Plus, since we looked at things during a specific four-month period in 2023, our findings offer a picture of that particular time, and things might have shifted since then. Lastly, by focusing on larger, multi-speciality hospitals, we might have missed some of the unique challenges and successes seen in other kinds of healthcare settings.

Competing interests

All authors declare no conflict of interest and no competing interests.

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References

Afzal, F., & Das, A. (2023). Predictors of antenatal health service utilization among left-behind wives of male outmigrants: Evidence from Patna District, India. *Asian Pacific Journal of Reproduction*, *12*(5), 220-228.

Afzal, F., Das, A., & Chatterjee, S. (2024). Drawing the linkage between women's reproductive health, climate change, natural disaster, and climate-driven migration: focusing on low-and middle-income countries-a systematic overview. *Indian Journal of Community Medicine*, *49*(1), 28-38.

Blanch, Shari & Anderson, Diana, Blog, (2023), Designing for Healthcare Sustainability: A Framework, American College of Healthcare Executives.

https:// www.ache.org

Centre for Environmental Health-(CEH) Case Report, (2019), solar energy initiative to avail financial and environmental benefits at Holy Family Hospital, New Delhi. https:// www.ceh.org.in

Celdran, A.H., Perez, M.G., Clemente, F.J.G. & Perez, G.M., (2018), Sustainable securing of medical cyber-physical systems for the healthcare of the future, Sustainable Computing Information System, 234 (2018), pp. 1-28. Google Scholar

Fiksel, J., Eason, T. & Frederickson, H., (2012). A framework for sustainability indicators at EPA. A Report of National Risk Management Research Laboratory, Sustainable Technology Division, U.S. Environmental Protection Agency.

Hensher, M. & McGain, F., (2020), Health Care Sustainability metrics: Building a safer, low-carbon health system, *Health Affairs, 39,* 2020.

India Brand Equity Foundation (IBEF) Report, (2022), IBEF is a Trust established by the Department of Commerce, Ministry of Commerce, Government of India, New Delhi (2022). https:// www.ibef.org

Afzal, F., Das, A., & Sahota, R. (2025). Perception and predictors of antenatal services utilization by left-behind wives of marginal solo outmigrants: empirical evidence from India. *Clinical Epidemiology and Global Health*, *34*, 102062.

Karliner, J., Slotterback, S., Boyd, R., Ashby, B., Steele, K. & Wang, J. (2020). Health care's climate footprint: the health sector contribution and opportunities for action, *Eur. J. Public Health*, *30*(5) (2020)

Marimuthu, M. & Paulose, H. (2016), Emergence of sustainability based approaches in healthcare: expanding research and practice. *Procedia: Social and Behavioral Sciences, 224* (2016), pp. 554-561.

Afzal, F., & Zaini, S. H. R. (2015). Quality Assurance in Manufacturing Industry-A Study on Link Locks Private Limited, Aligarh. *Al-Barkaat Journal of Finance & Management, 7*(2), 92-102.

Mehra, Rama & Sharma, Milind Kumar, (2021), Measures of Sustainability in Healthcare," Sustainability Analytics and Modeling, Volume 1, 2021, Elsevier Publications. https://www.sciencedirect.com

Rao, Vidya Priya,(2019), Building Patient Centric Hospital of Future, a Design Thinking approach, EH News Bureau, https:// www.expresshealthcare.in

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ISSN: 2581-3366

Sahota, R., Das, A., & Afzal, F. (2024). Determinants of data use for programmatic evidence-based decision making at peripheral public health care centres in Haryana, India. Clinical epidemiology and global health, 29, 101713.

Smith, H. K., & Harper, P. R. (2015). Can you model growth of trust? A study of the sustainability of a rural community health centre in North India. *Journal of Simulation*, *9*(2), 170-181.

Teenspire, (2021). Global Post, How can you leverage technology to achievesustainability? https: www.teenspireglobal.com

WHO- South Asia Regional Office, New Delhi Report, (2005), Safe Management of Bio-Medical waste Sharps In India-Case studies from Indian Hospitals. https://apps.who.int

Nitin Y. (2018), Patient Centric Healthcare in India. httpswww.highflyingcharters.com