GMR
The Original

DIGITAL HEALTH QUOTIENT OF INDIA: A SYSTEMATIC REVIEW OF READINESS, ADOPTION, AND MATURITY ACROSS STAKEHOLDERS

Rahul Lad[1*], Prof. (Dr.) Bhawna Sharma Padroo[2]

[1*]Research Scholar, Amity Business School, Amity University Maharashtra, India, ORCID ID: 0009-0007-7282-7882,
Email ID: 2009rahulld@gmail.com
[2]Director -International Affairs & Programs, Professor – Amity Business School Amity University Maharashtra, India,
ORCID ID:0000-0001-7201-9446

ABSTRACT
Digital health systems are rapidly transforming healthcare delivery through the integration of advanced technologies, data-driven decision-making, and patient-centered service models. This review paper critically examines the evolution, adoption, and readiness of digital health systems with a particular focus on the concept of the **Digital Health Quotient (DHQ)** as a multidimensional framework for assessing digital health maturity across healthcare stakeholders. The study synthesizes existing literature on digital health governance, technological infrastructure, stakeholder preparedness, and systemic enablers and barriers influencing digital transformation in healthcare systems. By integrating global experiences with the emerging digital health ecosystem in India, the review identifies key conceptual patterns, operational challenges, and implementation gaps affecting digital health performance and sustainability.
The findings highlight significant research gaps, including the absence of an India-specific DHQ measurement framework, limited longitudinal evidence on patient-centered outcomes, and insufficient empirical research on digital transformation within the pharmaceutical sector. The review emphasizes the need for context-sensitive strategies that strengthen digital infrastructure, promote interoperability, and enhance stakeholder digital capacity to support sustainable healthcare delivery. Overall, the study provides a structured analytical perspective to inform policymakers, healthcare institutions, and researchers in developing evidence-based digital health policies and improving healthcare accessibility, efficiency, and equity in emerging economies.

KEYWORDS: Digital Health, Digital Health Quotient (DHQ), Healthcare Transformation, Digital Health Readiness, Telemedicine, Health Information Systems, Healthcare Policy, Digital Infrastructure, India

1. INTRODUCTION

1.1 Concept of Digital Health

Digital health has emerged as a transformative force in modern healthcare, integrating information and communication technologies (ICTs) to improve healthcare delivery, accessibility, and patient outcomes (Alami et al., 2017). It encompasses a broad ecosystem that includes eHealth, mobile health (mHealth), telemedicine, artificial intelligence, big data, and digital therapeutics, all of which contribute to more efficient and patient-centered healthcare systems (Jandoo, 2020). In developing contexts like India, digital health plays a critical role in addressing persistent healthcare challenges, including infrastructure limitations, workforce shortages, and disparities in rural healthcare access (Ahmed et al., 2025).
Early conceptualization by Eysenbach positioned eHealth as an interdisciplinary domain combining medical informatics, public health, and digital communication technologies, emphasizing efficiency, patient empowerment, and improved quality of care (Neagoe & Grădinaru, 2025). The concept of connected health highlights continuous, data-driven patient engagement through technologies such as remote monitoring and teleconsultation systems (Bhavnani et al., 2017; Forstner et al., 2021). The rapid adoption of telemedicine and mobile-based health interventions—particularly during the COVID-19 pandemic—demonstrates the growing importance of digital platforms in expanding healthcare access and enhancing service delivery efficiency (LeFevre et al., 2022; Wadhwa, 2021; Paul, 2025).

1.2 Global Digital Health Landscape

Global adoption of digital health technologies has been shaped by differences in regulatory frameworks, technological readiness, and healthcare system capacity across regions (Bhavnani et al., 2017). Developed regions such as North America and Europe demonstrate advanced digital health ecosystems supported by strong governance, widespread Electronic Health Record (EHR) adoption, and robust data protection regulations, including initiatives driven by legislation such as the HITECH Act and privacy frameworks like HIPAA and GDPR (Galgate et al., 2024; Krzyzanowski & Manson, 2022; Hoofnagle et al., 2019). These regulatory systems have enhanced patient trust and enabled large-scale implementation of telehealth and digital therapeutics, particularly during the COVID-19 pandemic (Rashid et al., 2025; Kunkoski et al., 2025).

Regions within Asia-Pacific, Africa, and the Middle East have demonstrated rapid digital health innovation driven by government initiatives, mobile technology adoption, and artificial intelligence integration (Jakovljevic et al., 2021). Countries like China and Australia have invested in national digital health strategies and interoperable health records to improve service delivery and continuity of care (Tan et al., 2017; Vimalachandran et al., 2020). Meanwhile, mobile-based health interventions in African nations and smart healthcare initiatives in the Middle East illustrate how digital solutions can expand healthcare access in resource-constrained settings (Aboye et al., 2023; Kingiri & Fu, 2020; Mbunge & Sibiya, 2024; Karmakar & Sahib, 2017; Aldogiher & Halim, 2025).

These global experiences provide important benchmarks for assessing digital health readiness and informing the development of Digital Health Quotient (DHQ) frameworks in emerging healthcare systems.

Table 1: Global Digital Health Landscape – Comparative Overview

Region	Digital Health Characteristics	Key Policies / Frameworks	Technological Innovations	Challenges / Focus Areas
North America	Mature and technologically advanced digital health ecosystem with strong private-sector innovation and regulatory oversight.	HITECH Act (2009); HIPAA (1996); FDA Digital Health Innovation Action Plan	Electronic Health Records (EHRs); AI-driven diagnostics; Telehealth platforms	Data privacy protection; Interoperability; Balancing innovation with patient safety
Europe	Harmonized, patient-centric digital health systems emphasizing privacy and cross-border integration.	GDPR (2018); NHS Digital (UK); Digital Healthcare Act (DVG), Germany	NHS App; e-Prescriptions; Digital health applications (DiGAs); AI-enabled care	Cross-border data governance; Regulatory compliance; System interoperability
Asia-Pacific	Diverse and rapidly expanding digital health environment across developed and emerging economies.	Healthy China 2030; My Health Record (Australia)	AI-assisted diagnostics; Big data analytics; Telehealth and interoperable EHRs	Data privacy concerns; Regulatory inconsistency; Infrastructure variation
Africa	Mobile technology–driven digital health development focused on accessibility and outreach.	M-Pesa health initiatives; mTrac; MomConnect programs	SMS-based health communication; Mobile insurance; Teleconsultation services	Weak infrastructure; Connectivity limitations; Data security risks
Middle East	Emerging leader in smart and paperless healthcare aligned with national digital transformation strategies.	Smart Dubai; Dubai Health Strategy 2021; Saudi Vision 2030	AI and blockchain in health data management; Smart hospitals; Predictive analytics	System integration; Scalability; Cybersecurity management

1.3 Indian Digital Health Landscape

The development of digital health in India represents a significant transformation in healthcare delivery, driven by national policy initiatives, technological expansion, and public–private collaboration aimed at improving accessibility, affordability, and quality of care (Selvaraj et al., 2022). A major milestone in this transition was the launch of the National Digital Health Mission (NDHM) in 2020, later restructured as the Ayushman Bharat Digital Mission (ABDM), which established interoperable digital infrastructure linking patients, providers, and healthcare institutions through standardized health data systems and electronic health records (Bajpai & Wadhwa, 2020; Mishra et al., 2024; Ehrenstein et al., 2019). The integration of Health Information Exchange mechanisms and consent-based data governance frameworks has strengthened patient autonomy and data security while enabling evidence-based decision-making (Leckenby et al., 2021). Regulatory reforms, particularly the Telemedicine Practice Guidelines introduced during the COVID-19 pandemic, accelerated the adoption of virtual healthcare services and expanded access to care in underserved regions (Wadhwa, 2021). The rapid growth of mobile health applications and digital platforms has enhanced disease management, preventive healthcare, and remote consultation services, supported by increasing smartphone penetration and digital literacy (Abaza & Marschollek, 2017). The gradual adoption of electronic health records and the expansion of digital health startups have further strengthened India's digital health ecosystem, although challenges related to interoperability, implementation costs, and data privacy continue to influence system-wide adoption (Aggarwal & Roy, 2023; Joshi, 2024; Paul, 2024).

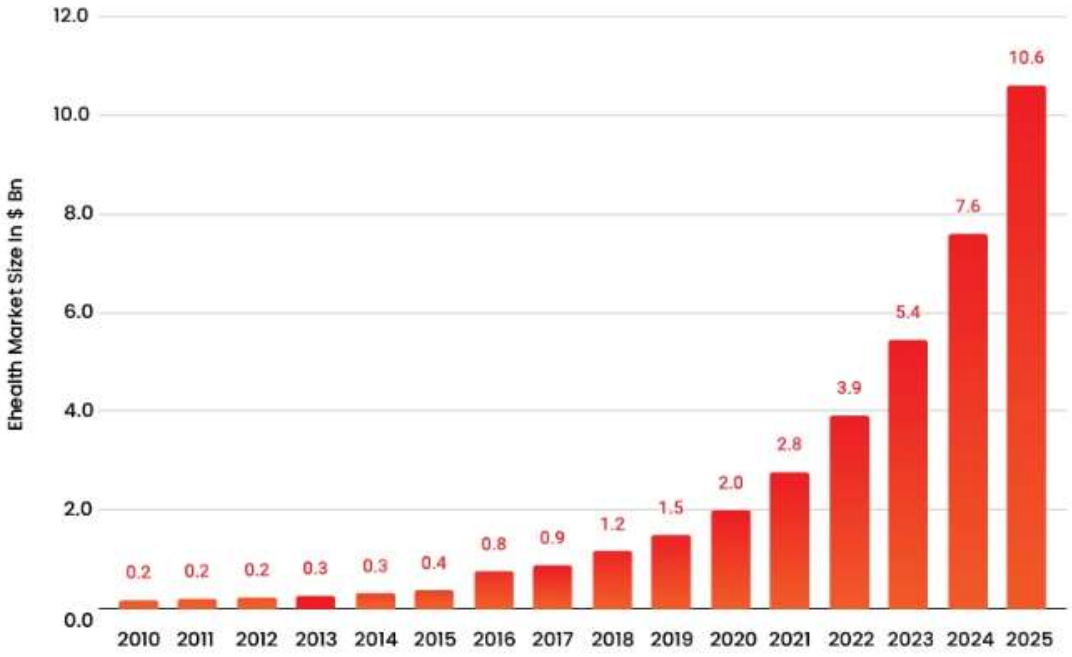

Figure 1 The eHealth market in India is expected to reach $10.6 Bn by 2025. Among the sub-sectors under eHealth, telemedicine has the highest potential and may reach $5.4 Bn by 2025.
Source: MedTel. (2022)

The Preventive Healthcare market has also proven to have myriad growth potential. The preventive healthcare market is expected to reach $197 Bn by 2025, growing with a CAGR of 22% as compared to 15% for the curative healthcare market.

Figure 2 Preventive Healthcare market
Source: MedTel. (2022)

The primary objective of this review paper is to critically examine the evolution, adoption, and readiness of digital health systems with particular emphasis on the concept of the Digital Health Quotient (DHQ) as a multidimensional framework for assessing digital health maturity across healthcare stakeholders. The review synthesizes existing literature on digital health governance, technological infrastructure, stakeholder preparedness, and systemic enablers and barriers influencing digital transformation in healthcare systems. By integrating global experiences with the emerging digital health ecosystem in India, the study aims to identify conceptual patterns, operational challenges, and implementation gaps that shape digital health performance and sustainability.

This review contributes to the literature by proposing a structured analytical perspective on digital health readiness and highlighting key research gaps related to measurement, interoperability, and stakeholder-level digital capacity. The insights generated are intended to inform policymakers, healthcare institutions, and researchers in developing context-specific strategies for strengthening digital health systems in emerging economies.

2. REVIEW OF LITERATURE

2.1 Digital Health Quotient (DHQ) Concept

2.1.1 Evolution of Digital Health Quotient (DHQ) as a Maturity and Competence Measure

The Digital Health Quotient (DHQ) is a concept that has developed into a necessary tool to calculate the digital maturity and competence of stakeholders in the healthcare ecosystem patients, hospitals, healthcare providers, and pharmaceutical

industry (Liaw & Godinho, 2023). Since the digital transformation of healthcare systems around the world occurs at a fast, it has also become necessary to evaluate not the existence of digital tools but the possibility to successfully utilize them to enhance health outcomes. DHQ is used as a complex index which assesses preparedness, adoption, literacy, and integration of digital technologies into healthcare systems. The intellectual foundation of the DHQ concept is based upon models of the digital transformation maturity applied to other industries, which evaluate digital preparedness based on the technological capacity, human adaptability, and the organizational culture. In the long run it has been narrowed down to solve the special complexities of healthcare like patient engagement, clinical workflows, data governance and interoperability.

In order to improve digital health maturity, a comprehensive view is not merely on the infrastructure or the level of technology adoption, but is a holistic state of digital literacy, inherent innovation, generating data, and ethical governance. A high DHQ represents a digitally empowered healthcare system or a stakeholder group, one that can apply technology effectively, safely and fairly. Due to the proliferation of digital health ecosystems worldwide, the necessity to make evaluations and cross-comparisons of progress has given rise to a range of measurement instruments that are specific to different stakeholders in healthcare. Some of these tools determine competencies of electronic health literacy, digital infrastructure maturity, telemedicine usability, and data governance capacity.

The determination of DHQ is especially relevant as its healthcare situation is quite diverse, and the rate of digital transformation can differ greatly across the regions or institutions (Fonda, et al., 2023). Although big metropolitan hospitals might boast of more developed electronic health records (EHR) systems and telemedicine technologies, smaller clinics and rural health care facilities might be lagging in digital transformation. DHQ frameworks make good insights on the areas that most need interventions, training, or investments. The subsequent paragraphs discuss the ways in which DHQ and related instruments have developed in four key areas, including patients, hospitals, the health care provider, and pharmaceutical organizations, which represent the varying aspects of the digital health competence.

2.1.2 Digital Health Quotient in Patients: The Digital Literacy and Digital Engagement

In the context of the patient, the concept of digital health literacy, which denotes the capacity to search, comprehend, examine, and utilize online health knowledge to make knowledgeable health-related decisions is forcibly related to the development of DHQ. With healthcare delivery more heavily reliant on virtual platforms, it is likely that patients will be using online portals, mobile applications, phone accessories, and teleconsultation devices. Nevertheless, such involvement cannot be achieved without access, but on the other hand, competence, and confidence in moving around online (Spanakis, et al., 2023). Multiple validated instruments have been created to identify these skills, and they include eHEALS (eHealth Literacy Scale), DHLI (Digital Health Literacy Instrument), and HLQ (Health Literacy Questionnaire). One of the oldest and most common tools that were created to measure the perceived skills of patients in locating, critically analyzing, and utilizing electronic health data is the eHealth Literacy Scale (eHEALS) by Norman and Skinner, (2006). It comprises eight items which assess confidence and self-efficacy to be able to use the internet to obtain health information and communicate with health providers through the use of the internet, eHEALS concentrates on functional literacy, the ability of the patients to search credible and online health information and engage with medical professionals using the internet (Coşkun & Bebiş, 2016).

The Digital Health Literacy Instrument (DHLI) builds on eHEALS by adding to it the concepts of protection of privacy, assessment of information and creation of content (Xie & Mo, 2023). HLQ is an interface between the digital literacy and traditional health literacy in the digital age (Cheng, et al., 2022). These tools combined constitute the basis of the patient-focused Digital Health Quotient that allows the researcher and policymakers to measure digital preparedness and pinpoint the areas of intervention.

2.1.3 Digital Health Quotient of hospitals: Evaluation of infrastructures and system maturity

In the case of hospitals, the DHQ framework is based on the focus on digital infrastructure, interoperability, data governance, and clinical workflow integration. The core of any digital health ecosystem is hospitals, and the state of their digital maturity is likely to have a significant impact on the performance of the entire system. Various established models of digital readiness in hospitals were created worldwide, such as the Digital Health Indicator (DHI) created by the HIMSS, the Electronic Medical Record Adoption Model (EMRAM), and the WHO Digital Health Maturity Model.

A detailed instrument designed by the Healthcare Information and Management Systems Society (HIMSS) to assess the hospital digital maturity in various aspects, the Digital Health Indicator (DHI) measures the hospitals on the dimensions of governance, interoperability, analytics, person-enabled health, and predictive health. It offers them a benchmarking approach in the international spectrum, which allows hospitals to evaluate their digital transformation process. The DHI model assisted in locating disconnects in the framework of India, such as the state of data sharing, cybersecurity, and integration of technologies accessible to the patient.

Another HIMSS framework, which is directly meant to measure the implementation and utilization of electronic medical records in hospitals, is the Electronic Medical Record Adoption Model (EMRAM) (van Poelgeest, et al., 2015). EMRAM is a system that distinguishes between eight stages of the progression of hospitals, with Stage 0 (no EMR) and Stage 7 (data-driven, fully paperless hospital). Every step reflects on gradual incorporation of digital systems, clinical decision support systems, and interoperability. EMRAM has been employed in hospitals all over countries like the U.S and Singapore to progressively develop their digital infrastructure. In the case of India, whose uptake of EMRs remains unequal, EMRAM can provide a systematic plan to complete digitalization.

The WHO Digital Health Maturity Model, which compliments these models, evaluates the health institutions and systems on key facilitators including leadership, strategy, data use, and workforce readiness (Brommeyer & Liang, 2022). It promotes self-assessment and assists nations to know which areas to put emphasis on capacity building. Such framework

implementation in the publicly run hospitals in India may indicate their preparedness and guide their policy development toward the rising of digital health.
All these tools taken collectively are what constitute the hospital-level DHQ, which offers a score of level of digital competence that is measurable. They focus not only on the implementation of technologies but also on their governance, patient satisfaction, and generation of value based on data. The high-DHQ hospitals are the ones that successfully incorporate EHRs, telemedicine, AI-based analytics, and cybersecurity into their business processes. This maturity, however, necessitates heavy investment, training and policy alignment, which has been difficult in the malleable healthcare environment in India.

2.1.4 Digital Health Quotient in Healthcare Providers: Test of Professional Competence/ Usability

To healthcare professionals, the Digital Health Quotient revolves around digital competence, telehealth usability and professional adaptability (Jarva, 2024). As digitization of health technologies finds its way into the service of the practice, clinicians need to prove their capacity to apply these technologies in an ethical and effective manner. This assessment is informed by two significant frameworks; the DigiComp-Health and the Telehealth Usability Questionnaire (TUQ).
DigiComp-Health model is a variant of the Digital Competence Framework (DigComp) developed by the European Commission, which presents the framework of digital competencies that healthcare experts must possess to operate in technology-intensive conditions. It includes five areas, including data literacy, communication, digital content creation, safety, and problem-solving. DigiComp-Health focuses on the ongoing learning and flexibility which are very important in a time when healthcare technologies are changing at a very fast rate. With this framework, institutions will be able to evaluate the willingness of providers to use such tools as electronic prescribing, teleconsultations, or AI-based diagnostic systems.
Another important tool called the Telehealth Usability Questionnaire (TUQ) is the questionnaire that is used to gauge satisfaction and ease of use of healthcare providers regarding their interaction with telemedicine sites (Parmanto, et al., 2016). TUQ was to assess such aspects as usefulness, ease of use, effectiveness, and satisfaction. The findings assist organizations to improve telehealth systems to address the issues of clinical and users needs. As an example, low TUQ ratings due to the usability of a tele Consultation platform can be marked by the necessity to consider a more appropriate interface design, workflow integration, or train clinicians.
High provider DHQ demonstrates the ability of not only proficient in the use of digital tools but capable of remaining empathetic, ethically upheld, and patient-centered (digitally). Digital competence among providers in India is however an imbalanced issue. In smaller hospitals, most doctors do not train in either telemedicine tools or data management systems. This gap can be overcome by incorporating models such as DigiComp-Health in medical education and continuing professional growth. Improving provider DHQ can also be achieved by providing assuring digital infrastructure, lessening the administrative load, and giving institutional assistance in adopting technology.

2.1.5 Digital Health Quotient of Pharmaceutical Industry: Digital Transformation and Innovation Capacity

The pharmaceutical industry has emerged to be one of the most important spheres of digital transformation impacting the sphere of healthcare as it uses technology in research, marketing, supply chains, and communication with patients. Within the scope of this industry, the measures of DHQ include data analytics and operational efficiency, as well as customer engagement and digital innovation. The McKinsey Digital Quotient (DQ) and the IQVIA Digital Maturity Model are two commonly used frameworks used to evaluate digital maturity in the pharmaceutical and life sciences. The McKinsey Digital Quotient framework (DQ) is used to assess the digital maturity in four dimensions, including strategy, capabilities, culture, and organization (Gökalp & Martinez, 2022).
IQVIA Digital Maturity Model provides a healthcare-related customization which contributes to innovation, connectivity, and analytics (REILLY & STOUT, 2015). It determines the efficiency with which a pharmaceutical firm can use online platforms to manage life cycle of products, compliance with regulatory measures, and patient centricity. As an example, relying on actual real-world information about wearable sensors and EHRs to aid in post-market monitoring and individual treatment plan development is an indicator of a high DHQ organization. The de-digitization of the pharmaceutical sector has been enhanced by the growth and heightened global competition in the industry, and the government emphasis on digital revolution in India.

2.2 Stakeholder-specific Review

The discussion of digital health practices among key stakeholders, including pharmaceutical companies, hospitals, healthcare providers, and patients, provides an inclusive insight into the way, in which digital transformation is impacting the healthcare systems and how Digital Health Quotient (DHQ) is shaped. All the stakeholders are vital nodes of the digital health ecosystem that bring their own distinctive contribution to its development and have certain problems with adoption, integration, and scaling. One of the first products to embrace digital technologies is the pharmaceutical industry, and this trend was mainly preordained by the necessity to be efficient, innovative, and regulate supply chains and marketing as well. Digital technologies have redefined the discovery of drugs and clinical trials in research and development. The algorithms of artificial intelligence (AI) and machine learning (ML) are now in common use to examine large datasets, pick possible drug candidates, and predict molecular interactions with a high degree of precision (Gupta, et al., 2021). Not only does this decrease the amount of time and expenses incurred in the process of R&D, but it also enhances the chances of success in preclinical and clinical phase. Pharmaceutical giants like Pfizer, Novartis, and AstraZeneca are already using AI based R&D pipelines and companies in India including Sun Pharma, Dr. Reddys laboratories and Cipla are also investing to have similar capabilities (Sharma, et al., 2024).

Digital technologies in medical research allow conducting decentralized clinical trials (DCTs) when patients take part remotely through wearable devices, mobile applications, and teleconsultations. The model itself became highly popular during the COVID-19 pandemic, and it was possible to run trials even in spite of mobility limitations. Online tools enhance adaptive design of trial, patient remote monitoring, and real-time data collection to enhance the speed and interactions. Digital transformation in pharmaceutical supply chain has resulted in increased transparency, efficiency and traceability.

The pharmaceutical industry has shifted from traditional promotion to data-driven digital marketing strategies that utilize social media, websites, email campaigns, and mobile applications to engage healthcare professionals and patients. Technologies such as predictive analytics and customer relationship management systems support personalized communication and disease awareness, while adherence to ethical and regulatory frameworks, including the Uniform Code of Pharmaceutical Marketing Practices, remains essential for maintaining transparency and trust. These developments contribute to improved innovation and efficiency in the national Digital Health Quotient (DHQ), although infrastructure limitations and regulatory ambiguity persist.

Hospitals represent a central pillar of digital health transformation, with Electronic Medical Records (EMRs) and telemedicine serving as key indicators of digital maturity. Policy initiatives such as the Electronic Health Record Standards of India (2016) and the Ayushman Bharat Digital Mission (ABDM) have strengthened interoperability and digital health governance, while the Telemedicine Practice Guidelines (2020) have legitimized virtual consultations and expanded access to care through platforms such as eSanjeevani. However, challenges related to cost, technical capacity, and cybersecurity continue to affect implementation.

Healthcare provider readiness and patient participation are critical determinants of national DHQ. Frameworks such as DigiComp-Health and usability tools like the Telehealth Usability Questionnaire (Hajesmaeel-Gohari & Bahaadinbeigy, 2021) support the evaluation of digital competence, while compliance with the Digital Personal Data Protection Act (DPDPA), 2023 ensures ethical data handling. Similarly, patient literacy tools such as eHEALS and DHLI highlight the importance of digital skills, trust, and equitable access in achieving a resilient and inclusive digital health ecosystem.

2.3 Digital Health Policies in India

To reach the desired destinations of establishing an effective digital ecosystem in India, A complex relationship exists between policy frameworks, technological advancements, and socio-economic conditions. The digitally empowered healthcare system vision in the country was boosted by the launch of the National Digital Health Mission (NDHM) later to be named as Ayushman Bharat Digital Mission (ABDM). In parallel with them, the development of regulatory frameworks governing telemedicine, digital health data security and cybersecurity also played a significant role in defining the outlines of digital healthcare provision in India. Despite these advancements, the issues of digital infrastructure, socio-economic inequalities, and privacy, remain key challenges influencing the discourse of the digital health quotient (DHQ) in India. This section critically examines the most significant regulatory framework, cybersecurity and privacy issues, and the socio-economic barriers to the implementation of digital health in India at large.

Among the milestones that the digitalization of healthcare can add to in India, one can distinguish the introduction of a digital healthcare platform called National Digital Health Mission (NDHM), which was initiated in 2020 under the Ayushman Bharat scheme. It will be the purpose of the mission to develop a single digital health ecosystem by building digital registries of healthcare providers, facilities, and patients, as well as forming a distinct Health ID. This ID helps people to have their health records stored, accessed and shared digitally in a secure and interoperable format. The NDHM operates under a vision of the easy flow of data among the healthcare providers to facilitate continuity of care, minimize duplication of tests, and give the power to patients to control their health information. The mission also aims to incorporate the telemedicine, e-pharmacy and health data analytics in a well integrated digital platform that facilitates access and efficiency in healthcare provision.

The Ayushman Bharat Digital Mission (ABDM) on the basis of NDHM has institutionalized these elements of digital health further and it has provided a national level electronic health data management framework. Interoperability standards, data privacy, and inclusivity, which are the main points in the architecture of ABDM, ensure the delivery of digital health services to remote areas. The flagship projects of the mission the Health Facility Registry (HFR), Health Professional Registry (HPR) and Ayushman Bharat Health Account (ABHA) are aimed at introducing transparency, accountability, and standardization in the medical care services. ABDM also strives to promote innovation whereby it allows the entry of the private players as well as startups to build on digital solutions in health according to the government protocols.

Along with these national initiatives, the regulatory environment in India has grown to encompass certain principles of telemedicine practice. In the context of the COVID-19 pandemic, the issue of remote consultation was a landmark when the Medical Council of India issued its Telemedicine Practice Guidelines in 2020. These principles outline the principles of patient consent, prescribing practice, data confidentiality and role of registered medical practitioners. They acknowledge the place of telemedicine as an accepted form of care where doctors can provide consultations through audio, video, or text-based communication devices. This has not only provided increased access to patients in rural and underserved nations, but has also given a systematic shape to the telehealth service providers. There are still problems in the area of ensuring continuous levels of quality, ethical considerations, and malpractices issues in virtual healthcare environments.

The digital debates have brought to the fore cyberspace dimensions of security and privacy in digital health, particularly at an unprecedented pace of digitization of medical records and patient data. Healthcare information is one of the most confidential types of personal information that includes medical records, diagnosis outcomes, prescriptions, and insurance information. The growing interconnectedness of health care systems provided by the electronic health records (EHRs)

and telehealth technologies increases the possibility of cyberattacks and data leaks (Aldosari, 2025). All these risks were aggravated by the absence of a comprehensive data protection law not so long ago. Data governance in healthcare has been recent with the adoption of the Digital Personal Data Protection Act (DPDPA) of 2023.

In the DPDPA codification, digital platforms and healthcare institutions are declared data fiduciaries, whose duty is to guarantee that data processing is conducted legally, consent is managed, and minimal information is contained in the data (Khanna & Kotwal, 2025). This is in line with the best practice standards of the world such as the GDPR of the European Union, which offers a legal base to safeguard patient information when undertaking digital health transactions. There still exist implementation issues, such as digital literacy of healthcare providers and compliance readiness of small and medium healthcare enterprises. Furthermore, the level of cybersecurity in Indian healthcare facilities is very heterogeneous as smaller hospitals and clinics do not always have the infrastructure to protect digital resources. Capacity building and awareness campaigns experience an urgent need to train healthcare workers on cybersecurity policies, encryption tools, and ethical approaches to data handling to ensure the years are within the range of competencies expected on the medical front.

In addition to regulatory and technological systems, socio-economic barriers are also another big hurdle towards a fair usage of digital health in India. The digital divide, characterized by the differences in access to internet connectivity, digital literacy and affordability are ideal factors that prevent all-inclusivity of digital health activities. The rural and remote areas where the infrastructure of health facilities is already in a weak state encounter further challenges of implementing digital tools. This is due to the low penetration of broadband, a poor power supply and a low number of smartphones and tablets which limits the potential of telemedicine and mobile health (mHealth) applications in these regions. A big portion of the population is digitally illiterate especially the older generation and the economically marginalized members who find it hard to participate well in digital health platforms.

Healthcare providers and institutions are also affected by the socio-economic landscape. Whereas big city hospitals have implemented advanced electronic medical record solutions and telehealth services, small clinics do not have access to the needed resources (financial as well as technical) to do it. The associated cost of digital transformation, such as investment in equipment and software, and training, is becoming a barrier to many small healthcare facilities. In addition, healthcare professionals have a learning curve to learn how to use digital tools, and resistance to change coupled with fears of workload and data safety tend to slow down the adaptation rates.

2.4 Research Gap & Justification

Although the digital health initiatives rapidly develop and technology is increasingly involved in the healthcare systems, the current state of research and implementation has multiple gaps that restrict the overall comprehension and assessment of the digital health maturity in India. Three main limitations in this list are which are the overall lack of India-specific Digital Health Quotient (DHQ) measurement framework, the lack of longitudinal patient-centered studies in researching the long-term digital health outcomes, and little empirical studies that primarily concentrate on the digitalization of the pharmaceutical sector. Those gaps not only limit the potential of the country in the evaluation of the advances, but also contribute to the hindrances involved in the process of developing evidence-based approaches that can increase the efficiency of healthcare, its accessibility, and equity. Among the gaps that are particularly urgent is the lack of a Digital Health Quotient (DHQ) measurement framework of Indian specifics. The units of the United States, the United Kingdom, and Australia have established universal frameworks to assess digital health preparedness, uptake, and effect on various stakeholders globally (Lennon, et al., 2017).

India does not have a multi-purpose tool reflecting its specific healthcare environment, socio-economic differences, and other infrastructural particularities. The realistic benchmarks can be found in existing models internationally, e.g., the HIMSS Digital Health Indicator or the McKinsey Digital Quotient, yet it does not consider any contextual specifics, including differences in digital literacy, regional infrastructure differences, and the overlapping of the public and private healthcare systems in India. As a result, no standardized measure can exist that shows the extent to which healthcare organizations, providers, and patients are going digital or how effectively the latter are enhancing care delivery. The needs to create an India-specific DHQ are critical in order to map the changes in digital health in the country so as to provide a way of directing policy intervention, investment priorities, and capacity-building efforts. It is also important that there is no longitudinal study of patients in the sphere of digital health.

Although there is much pilot projects and cross-sectional studies on the use of telemedicine, the use of mobile health app and the satisfaction of patients, not many studies have measured patient results in the long term. Longitudinal studies would be instrumental in the process of establishing how continued use of digital health platforms affect patient behavior, health literacy, treatment adherence, and clinical outcomes. As an example, ongoing surveillance by means of digital wearables or remote care services can contribute to improved access and efficiency at first, but the long-term consequences of such solutions in terms of health equity, the management of chronic conditions, and a psychological state have not been thoroughly studied. The lack of data on the interaction of demographic factors with patterns of using digital health in the long term (age, education, income, gender) makes such a pattern ineffective. The lack of this longitudinal evidence constrains the policymakers to assess the actual effect of digital health interventions in the real world setting, develop specific policies that benefit vulnerable groups, and make technology-based healthcare inclusive and sustainable.

The third research gap is a deficiency of research on the topic of digital transformation in the pharmaceutical industry of India, which is lacking in quantitative research investigations. The pharma industry is an important part of the digital health ecosystem more broadly, and innovations are occurring within the fields of drug discovery, clinical trials, supply chain management and patient engagement. The pharmaceutical companies of the world have used artificial intelligence technologies, data analytics and blockchain technologies to increase the efficiency and transparency of research.

Nevertheless, there is a lack of empirical studies on the manner in which Indian pharmaceutical firms are embracing these technologies and the obstacles encountered.
The majority of the literature available is descriptive or conceptual, with no quantitative analysis and metrics of sector-specific evaluation. This is a very worrying gap considering the fact that India has emerged as one of the largest generics medicine and vaccine producers in the world. Greater clarity of digital tools in changing efficiency of R&D, pharmacovigilance, and digital marketing would offer useful insights into how to increase competitiveness, compliance, and innovativeness capacity in the sector.

3. RESEARCH METHODOLOGY

This study adopts a qualitative systematic literature review approach to examine the evolution, adoption, and readiness of digital health systems with a particular focus on the Digital Health Quotient (DHQ) framework. The review synthesizes peer-reviewed journal articles, policy documents, and institutional reports related to digital health governance, technological infrastructure, stakeholder preparedness, and digital transformation in healthcare. The selected literature spans global and Indian contexts to enable comparative analysis and identification of contextual patterns influencing digital health maturity. The review process involves structured identification, screening, and thematic analysis of relevant studies published in recent years, ensuring the inclusion of credible and evidence-based sources.
The analysis is guided by key thematic domains, including digital health literacy, interoperability, healthcare infrastructure, and stakeholder-level digital capacity across patients, hospitals, healthcare providers, and the pharmaceutical sector. This approach enables a comprehensive understanding of how digital technologies such as telemedicine, electronic health records, and mobile health applications contribute to healthcare accessibility and system efficiency. The synthesis of global experiences with India's emerging digital health ecosystem supports the identification of research gaps related to measurement frameworks, longitudinal patient outcomes, and sector-specific digital transformation, thereby providing a structured foundation for future policy and research development.

4. THEORETICAL FRAMEWORK / CONCEPTUAL FRAMEWORK

The theoretical framework of this review paper is grounded in the concept of the **Digital Health Quotient (DHQ)** as a multidimensional model for assessing digital health readiness and maturity across healthcare stakeholders. The framework integrates perspectives from digital transformation theory, health systems strengthening, and technology adoption models to explain how governance structures, technological infrastructure, digital literacy, and institutional capacity collectively influence digital health performance. It assumes that successful digital health implementation depends not only on technological availability but also on stakeholder preparedness, regulatory support, and system interoperability.
The conceptual framework positions digital health readiness as a function of four core domains: governance and policy environment, digital infrastructure and technological capability, stakeholder digital competency, and health system integration and service delivery outcomes. These domains interact to shape healthcare accessibility, efficiency, and sustainability within evolving digital ecosystems. In the Indian context, the framework further recognizes contextual factors such as regional disparities, public–private healthcare coexistence, and variations in digital literacy, which influences digital health adoption and effectiveness.

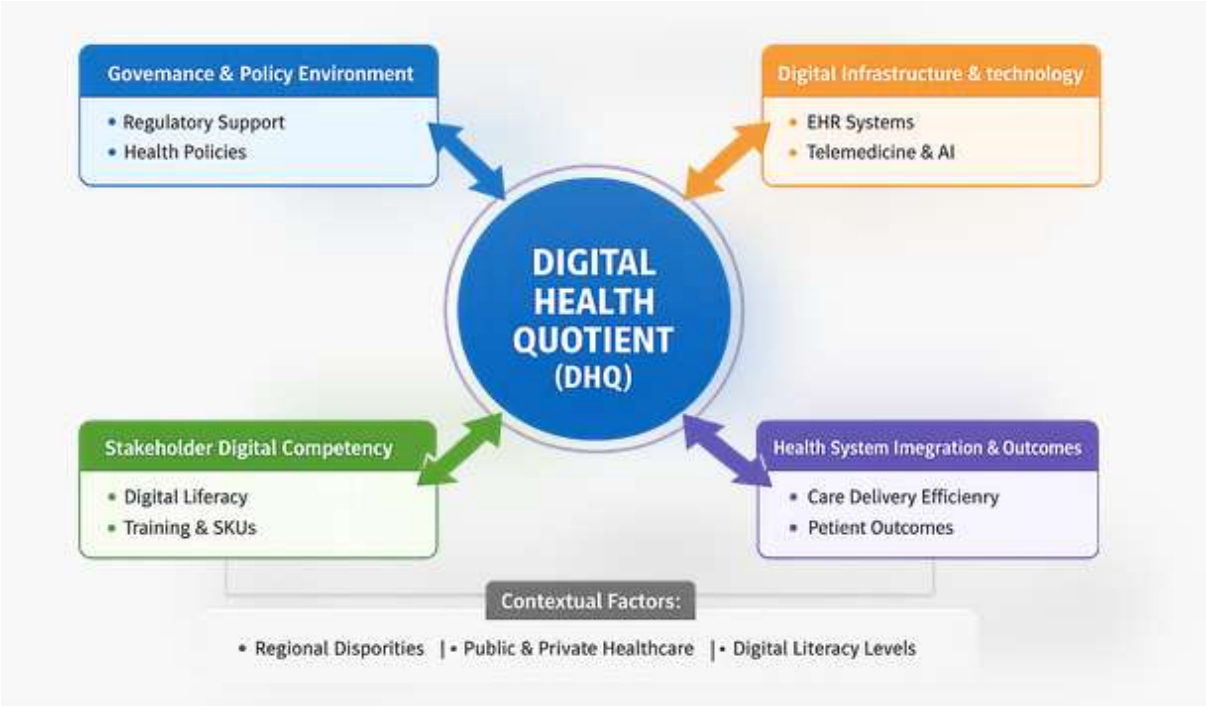

Figure 3 Conceptual Framework of Digital Health Quotient (DHQ)

Overall, this framework provides a structured analytical lens for evaluating digital health maturity, identifying implementation gaps, and guiding evidence-based policy and investment decisions in emerging healthcare systems.

5. DISCUSSION

The findings of this review highlight the growing importance of digital health systems as a central component of modern healthcare transformation. Across global regions, digital technologies such as telemedicine, electronic health records (EHRs), mobile health applications, and artificial intelligence have significantly improved healthcare accessibility, operational efficiency, and patient engagement. However, the literature consistently demonstrates that technological advancement alone does not guarantee successful digital health outcomes. Instead, the effectiveness of digital health systems depends on the interaction between governance frameworks, infrastructure readiness, stakeholder digital literacy, and institutional capacity. These interconnected factors collectively determine the level of digital health maturity within healthcare systems.

In the Indian context, the review identifies substantial progress in national digital health initiatives and the expansion of digital healthcare services. Nevertheless, persistent disparities in infrastructure, connectivity, and digital literacy across rural and urban regions continue to affect equitable access to digital health services. The absence of a standardized measurement framework, such as a context-specific Digital Health Quotient (DHQ), further limits the ability of policymakers and healthcare institutions to systematically evaluate digital health readiness and performance. Additionally, the limited availability of longitudinal patient-centered evidence and the lack of empirical research on digital transformation within the pharmaceutical sector represent significant knowledge gaps. These gaps constrain evidence-based decision-making and hinder the development of targeted strategies for improving healthcare delivery and system sustainability.

6. CONCLUSION

This review concludes that digital health transformation represents a critical pathway for strengthening healthcare systems, improving service delivery, and enhancing health outcomes in emerging economies. While global experiences demonstrate the potential of digital technologies to modernize healthcare systems, successful implementation requires a comprehensive and context-sensitive approach that integrates policy support, technological infrastructure, stakeholder readiness, and continuous system evaluation. The concept of the Digital Health Quotient (DHQ) provides a valuable analytical framework for assessing digital health maturity and identifying areas requiring strategic intervention.

Future research should focus on developing standardized DHQ measurement models tailored to national healthcare contexts, conducting longitudinal studies to evaluate long-term patient outcomes, and generating empirical evidence on digital transformation within the pharmaceutical industry. Strengthening these areas will support the design of inclusive, data-driven digital health policies and contribute to building resilient, efficient, and sustainable healthcare systems capable of meeting evolving public health demands.

REFERENCES

1. Abaza, H., & Marschollek, M. (2017). mHealth application areas and technology combinations. Methods of information in medicine, 56(S 01), e105-e122.
2. Aboye, G. T., Vande Walle, M., Simegn, G. L., & Aerts, J. M. (2023). mHealth in Sub-Saharan Africa and Europe: Context of current health, healthcare status, and demographic structure. Digital Health, 9, 20552076231178420.
3. Aggarwal, L., & Roy, M. (2023). A strategic roadmap to the successful implementation of digital health records in India. Seven Editora. Dec, 11.
4. Ahmed, M. M., Okesanya, O. J., Olaleke, N. O., Adigun, O. A., Adebayo, U. O., Oso, T. A., ... & Lucero-Prisno III, D. E. (2025, May). Integrating Digital Health Innovations to Achieve Universal Health Coverage: Promoting Health Outcomes and Quality Through Global Public Health Equity. In Healthcare (Vol. 13, No. 9, p. 1060). MDPI.
5. Alami, H., Gagnon, M. P., & Fortin, J. P. (2017). Digital health and the challenge of health systems transformation. Mhealth, 3, 31.
6. Aldogiher, A., & Halim, Y. T. (2025). Customer Engagement in Digital Health Transformation as Strategic Change: Evidence from Saudi Arabia's Vision 2030. Sustainability, 17(18), 8468.
7. Bajpai, N., & Wadhwa, M. (2020). India's national digital health mission.
8. Bhavnani, S. P., Parakh, K., Atreja, A., Druz, R., Graham, G. N., Hayek, S. S., ... & Shah, B. R. (2017). 2017 Roadmap for innovation—ACC health policy statement on healthcare transformation in the era of digital health, big data, and precision health: a report of the American College of Cardiology Task Force on Health Policy Statements and Systems of Care. Journal of the American College of Cardiology, 70(21), 2696-2718.
9. Brommeyer, M., & Liang, Z. (2022). A systematic approach in developing management workforce readiness for digital health transformation in healthcare. International Journal of Environmental Research and Public Health, 19(21), 13843.
10. Cheng, C., Gearon, E., Hawkins, M., McPhee, C., Hanna, L., Batterham, R., & Osborne, R. H. (2022). Digital health literacy as a predictor of awareness, engagement, and use of a national web-based personal health record: population-based survey study. Journal of medical Internet research, 24(9), e35772.
11. Coşkun, S., & Bebiş, H. (2016). Psychometric evaluation of a Turkısh version of the e-health literacy scale (e-heals) in adolescent. Gulhane Medical Journal.
12. Ehrenstein, V., Kharrazi, H., Lehmann, H., & Taylor, C. O. (2019). Obtaining data from electronic health records. In Tools and technologies for registry interoperability, registries for evaluating patient outcomes: A user's guide, 3rd edition, Addendum 2 [Internet]. Agency for Healthcare Research and Quality (US).

13. Fonda, F., Galazzi, A., Chiappinotto, S., Justi, L., Frydensberg, M. S., Boesen, R. L., ... & Palese, A. (2023, December). Healthcare system digital transformation across four European countries: a multiple-case study. In Healthcare (Vol. 12, No. 1, p. 16). MDPI.
14. Forstner, J., Bossert, J., Weis, A., Litke, N., Strassner, C., Szecsenyi, J., & Wensing, M. (2021). The role of personalised professional relations across care sectors in achieving high continuity of care. BMC family practice, 22(1), 72.
15. Galgate, H., Singh, R. P., Firdous, F., & Narwal, R. (2024). Electronic Health Records (EHR).
16. Gökalp, E., & Martinez, V. (2022). Digital transformation maturity assessment: development of the digital transformation capability maturity model. International Journal of Production Research, 60(20), 6282-6302.
17. Gupta, R., Srivastava, D., Sahu, M., Tiwari, S., Ambasta, R. K., & Kumar, P. (2021). Artificial intelligence to deep learning: machine intelligence approach for drug discovery. Molecular diversity, 25(3), 1315-1360.
18. Hajesmaeel-Gohari, S., & Bahaadinbeigy, K. (2021). The most used questionnaires for evaluating telemedicine services. BMC medical informatics and decision making, 21(1), 1-11.
19. Hoofnagle, C. J., Van Der Sloot, B., & Borgesius, F. Z. (2019). The European Union general data protection regulation: what it is and what it means. Information & Communications Technology Law, 28(1), 65-98.
20. Jakovljevic, M., Wu, W., Merrick, J., Cerda, A., Varjacic, M., & Sugahara, T. (2021). Asian innovation in pharmaceutical and medical device industry–beyond tomorrow. Journal of medical economics, 24(sup1), 42-50.
21. Jandoo, T. (2020). WHO guidance for digital health: what it means for researchers. Digital health, 6, 2055207619898984.
22. Jarva, E. (2024). Digital health competence of healthcare professionals in healthcare settings.
23. Joshi, H. (2024). Transforming healthcare: the advancement and future directions of electronic health records in the USA: an exploratory study. International Journal of Electronic Governance, 16(4), 428-452.
24. Karmakar, A., & Sahib, U. (2017). Smart Dubai: Accelerating innovation and leapfrogging E-democracy. In E-democracy for smart cities (pp. 197-257). Singapore: Springer Singapore.
25. Kingiri, A. N., & Fu, X. (2020). Understanding the diffusion and adoption of digital finance innovation in emerging economies: M-Pesa money mobile transfer service in Kenya. Innovation and Development.
26. Krzyzanowski, B., & Manson, S. M. (2022). Twenty years of the health insurance portability and accountability act safe harbor provision: unsolved challenges and ways forward. JMIR medical informatics, 10(8), e37756.
27. Kunkoski, E., Saha, A., & Kam, M. M. (2025, April). FDA Perspective on the Importance of Digital Health Technologies in Clinical Trials. In JAMA Health Forum (Vol. 6, No. 4, pp. e250165-e250165). American Medical Association.
28. Leckenby, E., Dawoud, D., Bouvy, J., & Jónsson, P. (2021). The sandbox approach and its potential for use in health technology assessment: a literature review. Applied health economics and health policy, 19(6), 857-869.
29. LeFevre, A. E., Shah, N., Scott, K., Chamberlain, S., Ummer, O., Bashingwa, J. J. H., ... & Whitehead, S. (2022). The impact of a direct to beneficiary mobile communication program on reproductive and child health outcomes: a randomised controlled trial in India. BMJ Global Health, 6(Suppl 5).
30. Lennon, M. R., Bouamrane, M. M., Devlin, A. M., O'connor, S., O'donnell, C., Chetty, U., ... & Mair, F. S. (2017). Readiness for delivering digital health at scale: lessons from a longitudinal qualitative evaluation of a national digital health innovation program in the United Kingdom. Journal of medical Internet research, 19(2), e6900.
31. Liaw, S. T., & Godinho, M. A. (2023). Digital health and capability maturity models—a critical thematic review and conceptual synthesis of the literature. Journal of the American Medical Informatics Association, 30(2), 393-406.
32. Mbunge, E., & Sibiya, M. N. (2024). Mobile health interventions for improving maternal and child health outcomes in South Africa: a systematic review. Global Health Journal, 8(3), 103-112.
33. MedTel. (2022). India's roadmap to digital health. Retrieved from https://medtel.io/indias-roadmap-to-digital-health/
34. Mishra, U. S., Yadav, S., & Joe, W. (2024). The Ayushman Bharat digital mission of India: an assessment. Health Systems & Reform, 10(2), 2392290.
35. Neagoe, I. E., & Grădinaru, G. (2025). Digital health defined by eHealth and mHealth: A bibliometric Analysis. In Proceedings of the International Conference on Business Excellence (Vol. 19, No. 1, pp. 201-215). Sciendo.
36. Parmanto, B., ALLEN NELSON LEWIS, J. R., Graham, K. M., & Bertolet, M. H. (2016). Development of the telehealth usability questionnaire (TUQ). International journal of telerehabilitation, 8(1), 3.
37. Paul, J. (2024, December). Cloud-Based Healthcare Platforms: Bridging the Gap in Rural and Urban Health Services.
38. Paul, J. (2025). Real-time predictive health monitoring using AI-driven wearable sensors: Enhancing early detection and personalized interventions in chronic disease management.
39. Rashid, Z., Ahmed, H., Nadeem, N., Zafar, S. B., & Yousaf, M. Z. (2025). The paradigm of digital health: AI applications and transformative trends. Neural Computing and Applications, 1-32.
40. REILLY, C., & STOUT, D. C. E. (2015). Big data.
41. Selvaraj, S., Karan, A. K., Srivastava, S., Bhan, N., & Mukhopadhyay, I. (2022). India health system review.
42. Sharma, G., Sharma, D., & Singh, S. (2024). Efficiency and Performance of Top Indian Pharmaceutical Firms: A Comparative Analysis. International Council for Education Research and Training, 2(02), 172.
43. Spanakis, P., Lorimer, B., Newbronner, E., Wadman, R., Crosland, S., Gilbody, S., ... & Peckham, E. (2023). Digital health literacy and digital engagement for people with severe mental ill health across the course of the COVID-19 pandemic in England. BMC medical informatics and decision making, 23(1), 193.
44. Tan, X., Liu, X., & Shao, H. (2017). Healthy China 2030: a vision for health care. Value in health regional issues, 12, 112-114.

45. van Poelgeest, R., Heida, J. P., Pettit, L., de Leeuw, R. J., & Schrijvers, G. (2015). The association between eHealth capabilities and the quality and safety of health care in the Netherlands: Comparison of HIMSS analytics EMRAM data with Elsevier's 'The Best Hospitals' data. Journal of medical systems, 39(9), 90.
46. Vimalachandran, P., Liu, H., Lin, Y., Ji, K., Wang, H., & Zhang, Y. (2020). Improving accessibility of the Australian My Health Records while preserving privacy and security of the system. Health Information Science and Systems, 8(1), 31.
47. Wadhwa, M. (2021). National Teleconsultation Service in India: eSanjeevani OPD.
48. Xie, L., & Mo, P. K. (2023). Comparison of eHealth literacy scale (eHEALS) and digital health literacy instrument (DHLI) in assessing electronic health literacy in Chinese older adults: a mixed-methods approach. International Journal of Environmental Research and Public Health, 20(4), 3293.