TECHNOLOGY IN HEALTHCARE: DETERMINING THE IMPACT, UNDERSTANDING THE CHALLENGES, AND IDENTIFYING POSSIBLE USE CASES OF TECHNOLOGY ACROSS THE HEALTHCARE DELIVERY PROCESS TO ENHANCE EQUITABLE ACCESS TO HEALTHCARE

MIHM-ISB REPORT 2020–2021

Technology in Healthcare: Determining the impact, understanding the challenges, and identifying possible use cases of technology across the healthcare delivery process to enhance equitable access to healthcare

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Executive Summary

The range of possible technologies in the healthcare sector is enormous. India's healthcare industry comprises hospitals, medical devices, health insurance, telemedicine, and medical tourism. The technology has advanced significantly, and the estimate is that effective implementation can result in care that is both higher in quality, more responsive to patients' needs, and, at the same time, more efficient (affordable and accessible).

This report studies the impact of technology on healthcare. It highlights various healthcare organizations, including established hospitals, healthcare centers, and healthcare start-ups, that have employed the latest technologies and have been a testimony to quality healthcare. This study also emphasizes on several concerns and challenges that these organizations have witnessed in adopting the technologies and how they affect various stakeholders. This study also examined several technological solutions that healthcare organizations used to deliver high-quality care at each stage of healthcare delivery. This is necessary to understand the similarities and differences in the approaches employed and helps establish the potential benefits and drawbacks of policies and frameworks affecting the different programs and projects' structure, design, implementation, and outcomes.

Technology is no longer considered a luxury. The healthcare industry needs to expand its frontiers to achieve genuine breakthrough performance. Healthcare leaders should consider building congenial ecosystems that embrace various sources of knowledge by honing their technological acumen. Healthcare companies should also consider piloting in increasing the scale, learn to embrace change, and evaluate new effective methods of providing affordable and accessible healthcare to all strata of society. Furthermore, healthcare organizations should strive to be agile in anticipating and adjusting their strategies as innovations continue to evolve.

Chapter I

Introduction

The Indian healthcare industry comprises hospitals, insurance companies, pharmaceuticals, medical devices, and diagnostic centers. As per the Human Development Report, India has just five beds for every 10,000 people and has poor statistics of having approximately eight doctors for every 10,000 population. Owing to a growing geriatric population and rising chronic care needs, the burgeoning demand augments India's need for a quality healthcare system. India is dedicated to achieving Universal Health Coverage as part of the Sustainable Development Goals (SDGs)[1]. The hospital sector accounts for about 71% of the total healthcare in terms of market size.
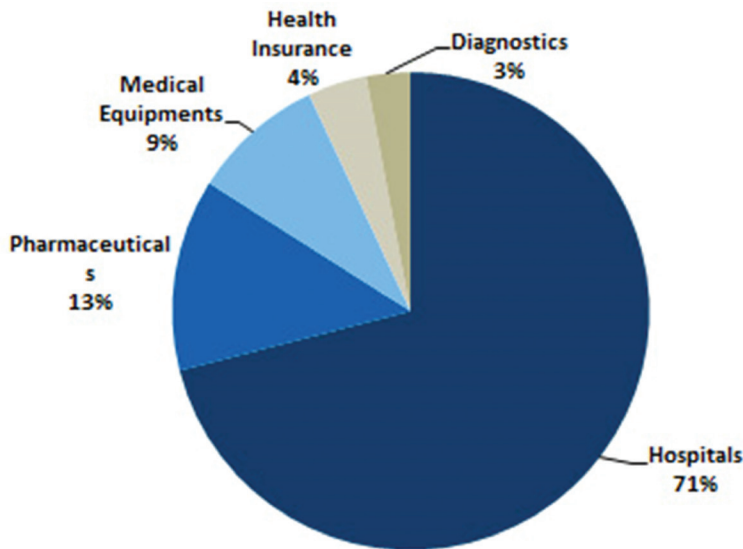
Source: Niti Aayog 2021.

The Union Budget 2021–2022 allocated a sum of INR 2,23,846 crore for health and well-being, as compared to INR 94,452 crore in 2020–2021[2]. The government also aims to increase its spending on healthcare to 2.5% of the GDP by 2025, in contrast with the current expenditure of 1.28% of GDP. This includes emphasizing more on preventive and primary healthcare. Moreover, the Indian healthcare sector is expected to generate 2.7 million jobs in India between 2017 and 2022, which amounts to over 500,000 new jobs per year.

The healthcare industry in India is projected to reach US $ 372 bn by 2022 from US $ 194 in 2020. The following graph exhibits the size of healthcare in India and the estimated growth[3].

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[1] These were set up in 2015 by the United Nations General Assembly and are intended to be achieved by 2030. They are the blueprint for achieving a better and more sustainable future for all by addressing global issues like poverty, inequality, climate change, peace, and justice.

[2] NITI Aayog, Investment Opportunities in India's Healthcare Sector (July 2021).

[3] India Brand Equity Foundation Report, 2021.

$ US Billion

Year	Value
2010	60
2011	68
2012	73
2014	81
2015	104
2016	140
2017	160
2020	194
2022	372
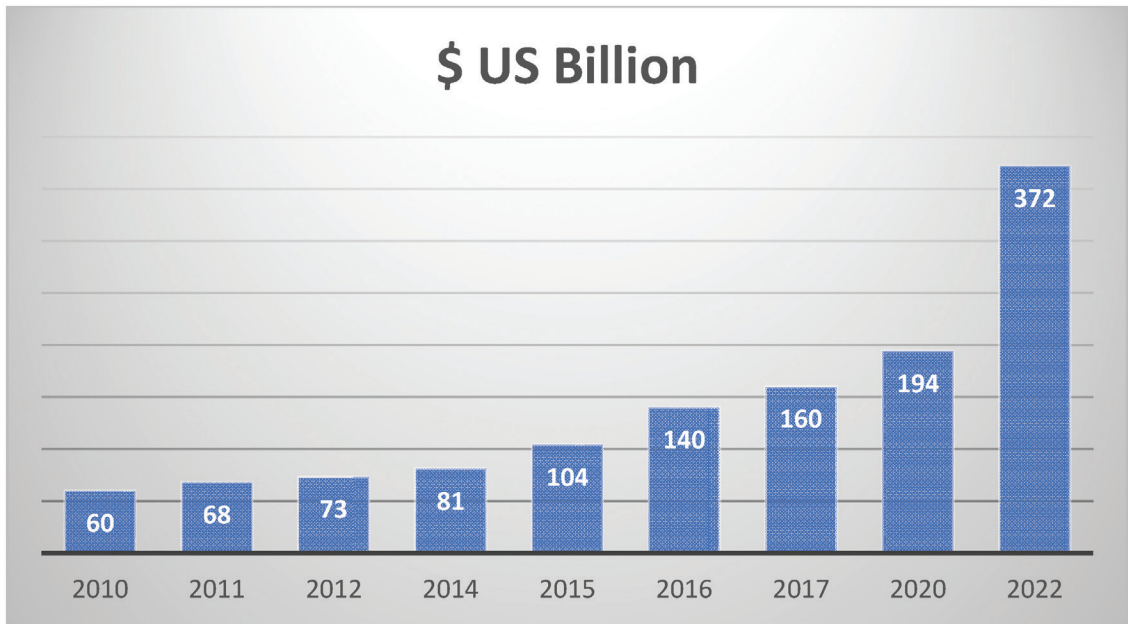
THREE LEVELS OF HEALTHCARE IN INDIA: PRIMARY, SECONDARY, AND TERTIARY HEALTHCARE

Healthcare, at its core, is essentially a public good. An ideal healthcare system is expected to entail accessibility to quality healthcare as a significant criterion. Furthermore, a fair distribution of the services to the patients' care adds to the yardstick of providing good healthcare. Primary healthcare is a unique approach that emphasizes preventive measures, management of chronic conditions, and promoting self-care. Primary healthcare is an effective approach to health and well-being centered on the needs of individuals, families, and communities. It focuses on the comprehensive and interrelated physical, mental, and social health and well-being aspects. A strong primary healthcare base is imperative to achieving universal health coverage in India, which is also instrumental in attaining other goals, including poverty eradication, hunger eradication, education, good hygiene, and economic growth, thereby reducing inequality. The World Health Organization recognizes the pivotal role of primary healthcare in achieving health and well-being for all ages.[4] As on March 31, 2019, there were 30,045 Primary Health Centers in India, of which 24,855 were in rural areas and 5,190 in urban areas.

Secondary healthcare is a treatment and support provided by doctors and other health professionals for patients whose primary care provider has referred them to a specialist for more specific care. This type of care is mainly imparted by a district or a regional hospital that offers outpatient and inpatient consultation services, including emergency care. In stark contrast to primary healthcare, secondary care is more specialized and helps patients in various health conditions by a healthcare specialist who is well-versed about the patient's condition.

Tertiary healthcare refers to the third level of the healthcare system. More specialized care is provided to patients. Often, this level of care is available in Tier-I and Tier-II cities. Additionally termed as super-specialty care, tertiary care caters to medically complex services for diagnosis and treatment. The services provided

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[4] Rural Health Statistics 2019

include advanced and complex procedures and remedies provided by medical specialists in state-of-the-art facilities.

IMPORTANCE OF TECHNOLOGY IN INDIAN HEALTHCARE

Technology in healthcare can help achieve the four essential A's concerning the community it serves: Awareness, Accessibility, Affordability, and Adaptability. In India, resources being scarce, and the demand for healthcare services being very high, solutions must be affordable, reliable, resilient, easy to distribute, and easy to use. Therefore, technology infusion is the key. Furthermore, in an emerging economy like India, technological innovations that are capable of lowering the cost of delivery of care while increasing volumes and enhancing the quality of care are more suited. Thus, the introduction of more advanced technologies that would be suitable for the needs of all segments of consumers has become a necessity.

Examples of technologies that have enabled delivering quality healthcare include:

- Screening & Preventive Care: Remote diagnostics has made it easy to operate machines that diagnose remote patients and transmit the data to specialist physicians.
- Internet of Medical Things (IoMT): This technology can reduce the cost of equipment maintenance by monitoring expensive equipment centrally.
- Telemedicine: This implies using information communication technology to enhance patient outcomes by boosting access to proper care and medical information.
- Remote-controlled Surgeries: Complex surgeries can be performed through remote-controlled robots in areas where quality healthcare access is poor.
- e-ICUs: These enable specialists based in a centrally located "command center" of a super-specialty hospital or a specialist ICU care-providing organization to read the vital health parameters of patients and guide the team stationed in the local hospital to deliver high-quality intensive care.
- Continuous Health Monitoring: This can be done through Telehealth, Artificial Intelligence, Virtual Patient Care, Remote Monitoring, and Genomics.

For India to provide equitable healthcare to all, it is imperative that technology and healthcare work seamlessly together. Considering the size of the healthcare sector in India, and given that the speed of change is accelerating, it becomes paramount to focus on addressing the challenges of affordability, adaptability, accessibility, and awareness. For instance, the adoption of Electronic Health Records (EHRs) is critical to impart quality care, reduce errors, and generate cost efficiencies by streamlining the clinical care processes to improve patient outcomes. Latest cloud-based solutions and mobile apps that consistently improve patient interactions will further boost the adoption of EHRs. Increasing awareness of health and wellness issues, including progressive door-to-door education, would promote healthcare-seeking behavior among patients, even driving many new-age apps dealing with continuous healthcare monitoring. Technology infusion, along with efficiencies from process improvements, would improve healthcare accessibility and affordability. As an example, technology has brought about significant efficacies in areas such as CT (computed tomography) scans, facilitating better images and faster diagnosis.

Chapter II

Literature Review

Technology can drive forward healthcare organizations with increased and fast-paced efficiency. Online and telehealth have emerged as new opportunities for patients to communicate and share medical data with medical experts.

Access to technology enables large numbers of people getting treated. Moving beyond telehealth and other healthcare websites, the push toward personal health records has appeared as a new option for patients to take control of their medical data and a push toward digitized healthcare (Ebrahim Randeree, 2009).

There are many prospective uses of Artificial Intelligence (AI) in managing medical procedures, especially during pandemic times. Recent advances in technology can help in the effective tracking and quarantine of cases. Smartphones and the Internet have helped detect and mitigate the impact of COVID-19 on patients. The ongoing process of infusion of modern technology in healthcare has contributed significantly in improving patients' lives. Procedures including diagnosis and radiology images, disease tracking, prediction of patient's health condition, protein structure predictions, drug discovery, etc., have accelerated with the infusion of the latest technology (Kumar Aishwarya et al., 2020).

IoMT has made a significant impact on the healthcare industry. Challenges still need to be addressed, including cyberattacks, leading to breach of medical data, managing large volumes of data, etc. However, IoMT can enhance decision-making and early disease diagnosis by smartly scrutinizing big data. All available medical resources are interconnected to provide effective and efficient healthcare services to everyone who needs medical assistance (Fadi AI-Turjman et al., 2020).

The use of Wireless Medical Sensor Networks enhances those who work for long hours treating COVID-19 patients, exposing themselves to possible infection, and risking their lives. To achieve proper quality healthcare to the general masses, a robust vision of deploying networks of sensors is required to achieve adequate quality healthcare. Several good practices have emerged from the current pandemic, while reducing the potential threat of COVID-19 transmission while treating others. During COVID-19, such technologies demonstrate the potential utility of powerful tools for social distancing in the clinical monitoring of patients (Ali Shokat et al., 2020).

Technologies such as telemedicine treat patients in remote locations by using telecommunication technology, enabling the exchange of medical information and data through advanced technological innovation from one place to another. It helps maintain social distancing as it aids in contactless consultations with the doctor and provides a suitable treatment option for the patients. Patients can receive better quality treatment without stepping out of their homes during the COVID-19 lockdown (Shashi Bahl, Ravi Pratap Singh & Raju Vaishya, 2020).

In an emerging economy like India, chronic and noncommunicable diseases constitute a significant public health challenge, including the choices related to allocating healthcare resources given the huge population. Technology in healthcare offers a platform to address these challenges relating to access and affordability. Technology in healthcare can bring about cost-effectiveness, thus enabling broad and equitable access to healthcare for all. Effectively, new drugs and medical technologies are available to consumers of healthcare. To the extent that the resources invested in healthcare in India are limited, Health Technology Assessment may be a means by which future healthcare expenditure in India can be allocated fairly and efficiently (Bastian Hass et al., 2012).

Although India has witnessed improvements in accessing healthcare, certain inequalities related to socioeconomic status, geography, and gender are multiplied with the increase in the financial burden of healthcare being met by households. Out-of-pocket healthcare expenditures aggravate poverty. The key challenges for achieving equity in healthcare services, financing, and risk protection in India are many. These challenges crop up due to disparities in resource allocation, insufficient access to high-quality health-care services, and the behavioral factors that affect the demand for appropriate healthcare. Employing equity metrics in healthcare, including monitoring, assessment, and investment in developing adequate knowledge base of health systems, is essential in achieving equitable healthcare in India. The implemen-tation of these prerequisites, along with a robust primary care service, will help to ensure more equitable healthcare for India's population (Y Balarajan, S Selvaraj & Dr. S V Subramaniam, 2011).

Telemedicine is considered the most effective and widely used method in remote diagnosis and treat-ment of patients employing telecommunications technology. It provides substantial healthcare to all sec-tions of society. It has come a long way in healthcare delivery and technology. The inception of the National Telemedicine Taskforce by the Health Ministry of India in 2005 paved the way for various projects like the AROGYASREE, VRCs, etc. It also aids in the family physician model by giving them easy access to specialty doctors for close monitoring of the patients. Services like telehealth and tele-education are a stepping-stone in the realm of healthcare. Acceptance of the latest technology, in addition to creating more awareness, can augment the primary, secondary, and tertiary healthcare systems. Governments, both at the central and state levels, have many initiatives for imparting knowledge and care in developing telemedicine practices, leading to a steady rise in interest in public health (Vinoth et al., 2019).

Chapter III
Technology in Indian Healthcare

Technology has enhanced the quality of healthcare. Several technologies, including the adoption of Telemedicine, EHRs, and AI, are the keys to improving the quality of healthcare, minimizing errors, and bringing about cost efficiencies by streamlining the clinical care processes to improve healthcare outcomes. For instance, the data gathered through EHRs, over a period of time, can help in further refining the analytics models to improve clinical outcomes. Technology further intensifies personalization and care. With the burgeoning chronic diseases, personalized care, depending on the illness and psychological make-up of the patient, plays a significant role in improving healthcare outcomes.

EMERGING TECHNOLOGIES: SHAPING THE FUTURE OF HEALTHCARE IN INDIA

Hospitals and other healthcare organizations that are well-equipped with the latest mobile healthcare applications and sensors are different forms of technology that have transformed the healthcare ecosystem. These enable the healthcare providers to perform their roles more efficiently by automating the real-time updates of patients' vitals and providing insights into the early detection of diseases. Relevant technologies aid in collecting, storing, and sharing critical patient data with the concerned medical authorities by adding an analytics layer to the process, thus providing a much better analysis of the patient's medical condition and treatment recommendations. Technologies such as Telemedicine/Telehealth and AI have been the stepping-stones that assist in the early detection of diseases. These further help track the patient's history. Moreover, the digitization of patient health records and implementation of Electronic Medical Records (EMRs) have been crucial in making such a transformation possible.

Various other technologies are also being used to empower healthcare providers to deliver a better quality care. For example, virtual reality (VR) and augmented reality (AR) pave the way for surgeries with the help of 3D views of the patient's organ that needs surgery. These can be analyzed in detail by the surgeons before performing the surgery. AR is used in medical education, where it can reduce the number of actual dissections and greatly help in studying human anatomy, histology, and embryology. 3D printing is favored due to its versatility of applications. With the future of healthcare focused on personalized care, the adoption of chatbots and AI assistants in this field is beneficial as it helps reduce the workload of doctors and ensures convenience for patients, in addition to aiding in therapy and providing 24×7 support for patients across the globe.

Digitization in healthcare organizations has proved to be immensely crucial for timely interventions in disease prevention and implementation of better treatment protocols. A few other examples of such organizations from the Indian context attest to the contribution of technology-enabled healthcare services.

- iKure delivers primary healthcare, wellness, and disease prevention services to remote communities in India through a combination of innovative technology, training, and sustainable business models.
- Nanohealth enables comprehensive healthcare provision by using an integrated technology solution that provides proactive and continuous care to patients, especially in chronic care management.

- Cloud Physician offers remote monitoring and advisory solutions to ICUs of different hospitals. It employs web-based healthcare applications, Machine Learning (ML), and AI to analyze patient data and provide timely clinical decision support.
- NIRAMAI offers an efficacious diagnosis for breast cancer by employing leading-edge technologies. Its proprietary Thermalytix, powered by AI, uses a high-resolution thermal sensing device and a cloud-hosted analytics solution to analyze thermal images. This is further aided by a web interface, SMILE (Software with Machine Intelligence for Life Enhancement), that helps upload demographic information about the patient and her thermal images. Testing on more than 4,000 women in 12 hospitals/diagnostic centers and screening camps suggests the high accuracy of the company's solution.
- BrainSightAI merges AI and Neuroscience to enable higher precision in diagnosing neurological and psychiatric problems in patients. It does so with high levels of accuracy. It provides faster and deeper insights relating to these problems, which helps in the earlier detection of psychotic disorders.

BREAKTHROUGHS IN INDIAN HEALTHCARE

Telemedicine

Telemedicine has enormous potential in meeting healthcare delivery challenges in rural and remote areas, besides several other applications in education, training, and management in the health sector. Telemedicine entails the process of remote diagnosis and treatment of patients employing telecommunications technology, thereby providing good quality healthcare to low-income segments. The earliest published telemedicine record was in the first half of the 20th century when ECG was transmitted over telephone lines. From then to today, telemedicine has come a long way in healthcare delivery and technology. NASA and ISRO contributed to this. Telemedicine started in 1999 in India, recognizing its vast potential.

[5]On March 17, 2021, the Health Ministry's eSanjeevani telemedicine service crossed 3 million (30 lakh) teleconsultations since its launch, enabling patient-to-doctor consultations from the confines of their homes as well as doctor-to-doctor consultations.

"Your doctor is just a click away!!"

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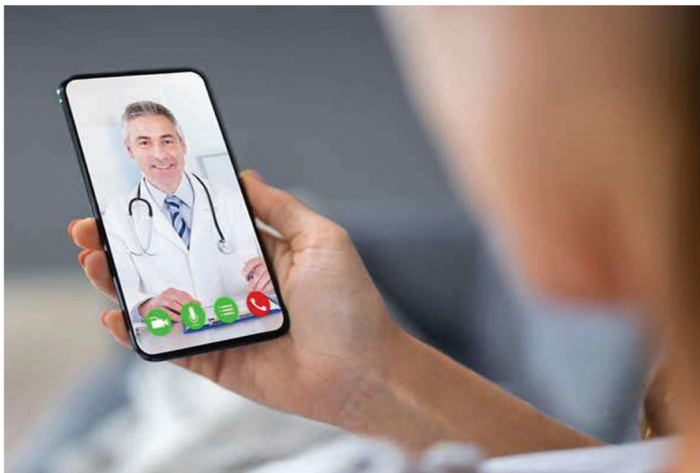
[5] Ministry of Health and Family Welfare, 2021.

Telemedicine is a fast-emerging sector in India. Major hospitals and healthcare start-ups, including Apollo, AIIMS, Karma Primary Healthcare Pvt Ltd, and Narayana Hrudayalaya, have adopted telemedicine services and entered several PPPs (Public–Private Partnerships). It also helps family physicians by giving them easy access to specialty doctors and closely monitoring patients.

Telemedicine can bridge the rural–urban divide in medical facilities, extending low-cost consultation and diagnosis facilities to the remotest areas of the country via high-speed Internet and telecommunication.

These technological breakthroughs have been very advantageous for patients in accelerating immediate access and convenience to healthcare specialists, good patient engagement, and improved quality of care delivery. It has increased cost-effectiveness and also enables fewer hospital visits. During COVID-19, it was a boon for many patients who could not move around due to lockdowns. Catalyzed by the widespread adoption of telemedicine during COVID-19, it is now widely accepted across various healthcare-seeking segments.

For Service Providers (Physicians), technology infusion has helped with better decision-making and enhanced efficiency, reducing travel time especially in large cities. It has further hastened the process of better patient follow-up with a consequent increase in revenues for the doctors. Consequently, telemedicine is emerging as a promising field for better health delivery for primary care and secondary care.

Pioneers in Telemedicine

- Karma Healthcare has been the pioneer in primary healthcare delivery in remote areas, adopting various technology models, including telemedicine/telehealth, robust quality assurance systems, IoT (Internet of Things)-enabled services, and e-Clinics. Their solutions are cost-effective, reliable, accessible, and accurate in diagnosis and treatment.
- Glocal Healthcare uses telemedicine and various digital dispensaries in providing quality healthcare to patients. The physicians leverage technologies to deliver complete primary and secondary healthcare solutions such as consultation, prescribing and interpreting results of confirmatory tests, and prescribing medicines.
- Vidmed is a telehealth enterprise that fuses technology and pharmacies to simplify communication among the doctor, the patient, and the pharmacist. The company delivers convenient virtual care that improves outcomes, reduces costs, and boosts revenues.
- eSanjeevani is a browser-based application that facilitates both doctor-to-doctor and patient-to-doctor teleconsultations. It has a user-friendly graphical user interface and is developed on .Net technology using a 3.5 framework with MS-SQL as the database. This eases the process of seeking medical advice and dispensing relevant medication prescriptions through audio and video interfaces. People residing in remote areas are able to get their health-related consultations in a hassle-free manner.

Artificial Intelligence: Transforming Healthcare!!

AI is a technology that is widely considered as the most relevant technology that helps provide quality access to all relevant stakeholders in healthcare. AI helps improve the accuracy of diagnosis, provides personalized medical care, helps prevent illnesses, and enables the discovery of new treatments. The use of AI is expected to increase 10-fold within the next 5 years.

AI employs coded computer software routines, which are known as algorithms, with precise instructions to perform tasks that would otherwise necessitate decisions made by the human brain. Such software helps to understand and process vast amounts of data, process sounds and images, and use learning patterns to solve clinical problems. It facilitates interaction that provides a machine the ability to function "like" a human.

"AI combined with robotics is the new nervous system for healthcare."

Applications

Following are some of the current technological applications of AI in healthcare:

- <u>Medical diagnostics</u>: AI is helpful in diagnosing patients with specific ailments.
- <u>Drug discovery</u>: Several pharmaceutical and healthcare companies are currently leveraging AI to help with drug discovery and enhance the related clinical processes.
- <u>Clinical trials</u>: Until the advent of AI, most clinical trials were managed offline with no integrated solutions that could effectively track the patients' progress, data gathering, and clinical outcomes. AI has been instrumental in revolutionizing clinical trials by efficiently managing the intricacies of diagnosis and treatment.
- <u>Improving patient outcomes</u>: Patients' outcomes can be enhanced by adopting a wide variety of strategies and outcomes driven by AI. For instance, advances in medical imaging have significantly contributed to the accuracy of screening for diseases and aiding in early detection. This, in turn, leads to more accurate treatment and better patient outcomes.

Pioneering Examples

- <u>Fluid AI</u> is a start-up that employs AI to provide solutions across a wide variety of sectors. It uses algorithms that enhance the ability to better predict the progress of a disease condition by moving beyond simple mathematical relations and correlations to develop a learning framework that develops an integrated and deep understanding of the problem.
- <u>Qure AI</u> provides AI to enable accessible, affordable, and timely healthcare across the globe. Its offerings encompass a wide variety of applications, including preventive screenings, early detection, emergency care, institutional disease response, and treatment adherence, by enabling seamless workflow optimization across the care continuum.
- <u>MFine</u> is a mobile application that aims to provide hassle-free and easy medical consultation for patients and healthcare users. This AI-powered platform allows people to seamlessly chat with a doctor.

- <u>SigTuple</u> is an AI-based healthcare diagnostic solution that employs an ML platform called Manthan, which can provide insights from the data. It enables deep learning to detect and predict the chances of a person having a particular disease based on advanced processing of medical diagnostic images.

AI has the potential to bring new efficiencies and quality to healthcare outcomes in India. However, the challenges to its adoption in the healthcare sector include inadequate funding, insufficient healthcare infrastructure, and deeply embedded sociocultural practices. Even now in India, there are several areas with poor digital infrastructure. The sector is also characterized by a lack of standardization and is relatively unregulated. The effectiveness of these technologies will depend on the accurate identification of problems and matching them with appropriate solutions.

Chapter IV
Research Methodology

The study used secondary data for the research. The research focused on various healthcare organizations that employed the latest technologies. The study also examined several technological solutions that healthcare organizations use to deliver high-quality care at each stage. Data were collected from the respective organization's websites, ISB's LRC, and government databases, including census reports and annual reports of companies. Sources of data also included research reports by various researchers and universities in relevant areas. Relevant books authored by several authors and articles on technology in healthcare in magazines and newspapers were also accessed.

The analysis was undertaken to identify successful use cases of available technologies. The research team also aimed to discern relevant concerns and challenges faced by users in adopting these technologies and understand the areas of healthcare delivery where technology can facilitate the twin objectives of addressing the challenges of access and quality of healthcare.

SUMMARY OF FINDINGS

Digital technologies are shaping the future of healthcare in India. The use of digital technologies empowers and augments the capabilities of the healthcare workforce and improves the quality of primary healthcare in the far-flung hinterland of India, as well as secondary and tertiary care in the larger cities.

However, technology opens up several challenges and risks, which need to be understood and addressed. For instance, patients and healthcare professionals who rely on the digitalization of data to make treatment decisions depend on correct and accurate datasets. The alteration of the relevant data can lead to a wrong diagnosis or treatment plan, in turn resulting in adverse events. Furthermore, in the worst-case scenario, without correct security protocols, such breaches can result in serious misdiagnosis, with dire consequences from the perspective of the patients.

Dealing with upgraded technologies, including teleconsultations, leads to a reduction of human touch between the patient and the doctor during the treatment process. From the patient's perspective, it could be perceived as a lack of empathy. Especially for the elderly and the most vulnerable patients, relying on technology as the care interface can cause confusion and frustration. It can also result in treatment plans not being understood correctly and patient noncompliance.

Chapter V

Data Analysis

The study was conducted to investigate the possible implications of the technology on healthcare. The research explored a whole spectrum of healthcare organizations for a more comprehensive analysis. The study considered hospitals, healthcare start-ups, diagnostic centers, and pharmaceuticals that employed the latest technologies in their various processes. Secondary data were the primary source of information. This involved delving deep into various healthcare reports, academic journals, and government archives, which led to several important findings.

Technology in healthcare has seen a lot of changes in the past few years across the country. In the quest for quality clinical outcomes coupled with cost-effectiveness, people are keen on less invasive treatments and better quality of life. Moreover, they are also looking for more personalized and affordable healthcare, triggering the need for more healthcare services and more accessible healthcare options. Exemplary healthcare organizations are constantly innovating, striving to improve their services, and make them more accessible for those who need healthcare services the most. Besides, after the COVID-19 outbreak, there has been a massive shift in acceptance of technology in healthcare, both from provider and patient perspectives.

Several healthcare start-ups and established organizations have been testimony to the favorable impacts of technology in healthcare. The research methodology adopted was based on factual data collection followed by a perceptual survey of several leading healthcare organizations. The data sheets created for each healthcare organization that aggressively adopted technology focus on the following broad information areas: usage of the current technologies, accreditations, innovation models adopted by the healthcare organizations, benefits accruing to the end users, range of services, etc. Following are a few notable examples taken from an exhaustive list from the Indian context that attest to the power of technology-enabled healthcare services (for other details, refer to Annexure I).

Karma Healthcare Pvt Ltd is the pioneer in employing technology that aims at providing quality and affordable healthcare to all, especially in rural areas. It was founded in the year 2014 by Mr. Jagdeep Gambir, an alumnus of the Indian School of Business. It currently has 25 clinics spread across Rajasthan, Haryana, and Madhya Pradesh and serves 100–150 patients a day. The organization adopts leading technologies including telemedicine and IoMT-enabled services. These technologies are scalable and seamlessly connect to large-scale technologies such as WhatsApp, AWS (Amazon Web Services), and Cloud Telephony solutions. A study conducted by SocioCatalyst, a management consultancy firm, demonstrates the benefits accrued, including 98% of women reporting improved health status, 90% of the patients getting back to work faster due to timely treatment due to Karma e-Doctor clinics, and benefits accruing in

terms of saving time and money for both providers and patients, compared to other options. Improvement in quality care soared to 94% after widespread technology adoption, up from 62% before large-scale technology roll-out.[6] Karma is also planning to expand its horizon to semi-urban and urban areas, replicating its e-Doctor clinic models, in addition to launching innovative health insurance products for the rural markets.

Ruby Hall Clinic stands out as one of the leading organizations in employing technologies, including telemedicine, robotic surgery, and adopting the latest digital PET-CT scan for early detection of cancer. This led to prominent changes in the clinical outcomes, including effective monitoring through video consultations that also facilitate hassle-free processes for both doctors and patients. With the advent of robotic surgery, various benefits are observed, including shorter hospital stay, faster recovery, reduced risk of infection, and minimal scarring. Telemedicine makes it possible to leverage the expertise of specialists who are remotely located. It provides a cost-effective method of seeking expert opinions remotely.

NIRAMAI was founded by Dr. Geeta Manjunath in 2016 with the sole objective of detecting breast cancer through the adoption of advanced technology entailing Thermalytix powered by AI. NIRAMAI has developed a novel software-based medical device to detect breast cancer at a much earlier stage vis-à-vis traditional methods, with a unique solution that is low cost, accurate, automated, and a portable cancer screening tool, which ensures privacy for the patient during the process of diagnosis, as there is no need for a technician to be present while the thermal scan is being done. The imaging method, which is radiation-free, contactless, and painless, works for women of all ages. The core technology has been developed using patented ML algorithms for more reliable and accurate detection of breast cancer. This start-up runs on three main rationales: noninvasiveness, ensuring patient privacy, and high accuracy. This has resulted in a significant enhancement of clinical outcomes. The system has been tested on a large population set, with

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[6] Karma's documents

more than 4,000 women in 12 hospitals/diagnostic centers and screening camps. The results indicate high levels of accuracy, often better than the usual method of Mammography. The Thermalytix is effective in detecting cancer lesions as small as 4 mm, even before the onset of palpable lumps. NIRAMAI's network spans across 12 hospitals nationally, and it is expanding rapidly.

Aindra is building a data-driven, rapid testing, and patient-focused clinical pathology system that uses AI to build detection tools for several critical ailments. It builds on key objectives of faster diagnosis, farther outreach, and increased throughput. CervAstra was the first product launched by the company to detect cervical cancer. It is a cost-effective initiative leveraging the company's advanced computational pathology platform. CervAstra was used by 700 women across rural areas in Karnataka including Tumakuru and Chikballapur, as well as in urban areas including Bengaluru.

TECHNOLOGY ASSESSMENT IN PRIMARY HEALTHCARE

Technology is no longer a luxury in all realms of healthcare. Primary healthcare has been grappling with challenges of accessibility, affordability, and adaptability. Addressing these challenges necessitates the pursuit of more equitable, comprehensive, and integrated models of healthcare. Digital technologies of all kinds have become imperative in primary care and their penetration is growing, witnessing rapid integration of technology in a range of areas that support primary care and essential public health functions. A few common uses of digital technologies in primary healthcare include seamless access to medical knowledge resources, facilitating effective clinical support, remotely monitoring the care being provided, and monitoring the spread of communicable diseases, as well as tracking supplies of drugs and vaccines.

TECHNOLOGY ASSESSMENT IN SECONDARY HEALTHCARE

Although digital technologies have the potential to transform healthcare, the uptake in secondary care has only gained momentum in the recent past. The change for more widespread adoption is likely to be ushered in patients using digital tools at every step of their health journey. This includes access to their health records containing secondary and community care information, mobile apps that interface with records, and integrating data sharing across various key applications relevant to the patient.

One of the few leading healthcare organizations that successfully employ technology in secondary healthcare is Glocal Healthcare. This organization has innovated a novel digital dispensary with the motto, "Good Health Knows No Barriers." With its vast pool of doctors, extensive reach, and commitment to quality health for all, Glocal Digital Dispensary is uniquely positioned to navigate health and technology in directions that will benefit local, national, and global communities. A few key technologies that it adopts are HelloLyf, with the tagline, "Wherever You Go, Our Health Network Follows." This telemedicine app facilitates contactless video consultations with doctors and specialists for patients anytime and anywhere, thus obviating the need for patients to wait in long queues, while seeking healthcare.[7] Glocal Healthcare is in the process of setting up 550 Telemedicine Centres in the districts of Rewa, Jabalpur, and Sagar in Central India.

Technology has accelerated the speed of medical output, as more patients can be handled in a given period of time. The data stored can be retrieved at the click of a button. All the records of patients are digitized so that doctors can easily access the patient's treatment history and diagnostic reports. For diagnostics, the provision of improved and digitalized x-ray and other diagnostic points of care devices ensure greater accuracy and quicker results. Tech-enabled healthcare solutions are not a luxury but a necessity. When a woman in a remote village, many kilometers away from the nearest healthcare facility, is visited by a frontline worker and undergoes a teleconsultation session with a doctor, and her healthcare issues are addressed, she begins to experience the benefits of technology in healthcare.

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[7] https://www.ghspl.com/

"Technology driven healthcare process."
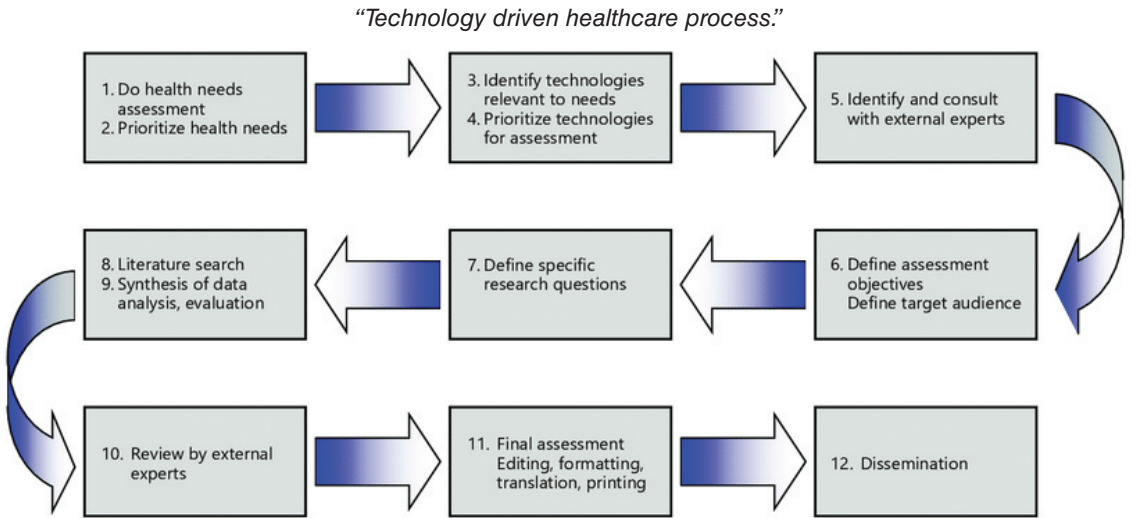
Source: Glocal Healthcare documents.

However, medical technology industry needs to evolve from merely supplying devices and equipment to the healthcare industry, to providing integrated solutions for improving healthcare outcomes. Many of the companies have progressed in healthcare innovations that are cost-effective. The need is for both radical innovation and incremental innovation, with the objective of having the potential to influence large segments of the population, which is mostly driven by affordability.

Chapter VI

Recommendations

Although digital transformation in healthcare has been able to address challenges of accessibility, adaptability, and awareness, the healthcare system calls for certain measures that would further facilitate smooth, affordable, and efficient clinical outcomes.

The two most significant contributors would be the government and industry.

The government is the most important contributor to providing a conducive policy framework for the improvement of medical technology in healthcare in India. Besides, the industry members must also work jointly with the government to ensure breakthrough innovations in healthcare in order to achieve sustainable growth. Quality standards in tune with the relevant global standards for medical innovations must be enforced. PPPs with various medical organizations and healthcare providers are an effective pathway for rapid scaling. The resulting synergies will facilitate employing the latest technological innovations, enhancing quality, and implementing cost-effective methods of healthcare delivery. Such partnering will ensure that affordable healthcare delivery reaches the masses rapidly.

Many health workers, mostly in rural areas, experience logistical challenges while using digital health technologies that include poor connectivity and reliable access to electricity. Health workers are in need of reliable equipment and ongoing technical support.

Encouraging relevant R&D through financial support to companies for process and product commercialization is another high-potential avenue for the government to pursue. Additionally, expansion of local R&D capabilities including the establishment of medical research centers to foster innovations would further boost technology adoption in healthcare. Engaging with the insurance providers to improve the health insurance coverage for medical technology products is an avenue that must be pursued in parallel to minimize disconnects across the healthcare value chain.

Improving accessibility, increasing the numbers of technically competent, certified healthcare workers in communities, certification and registration of such professionals and providers, etc., will be essential to ensure the last-mile reach of technology-enabled healthcare access for the masses.

Chapter VII

Conclusion

Technology is vital to delivering good-quality healthcare services, especially in geographies with a low density of doctors, as is the case in rural India, where most of the Indian population lives. The accessibility of healthcare facilities in India is skewed in favor of the affluent sections of the people in urban India. India has world-class doctors, clinics, and technologies at the high end. However, most of the country's population cannot afford anything better than primary healthcare, which itself has a lot to be desired. Accessibility in remote areas is restricted by an acute shortage of healthcare facilities and professionals. Technology is imperative in such resource-constrained environments to bridge the divide between the healthcare "haves" and "have-nots."

Digital technologies have already unplugged plenty of opportunities in shaping the future of primary healthcare in India. They are ushering in a host of changes in policy and practice while creating new patterns of communication, empowerment, and engagement among the key stakeholders in the communities served. The use of digital technologies empowers and augments the capabilities of the healthcare workforce and improves the quality of primary healthcare in the far-flung hinterland of India.

This study identified various implications of technology in Indian healthcare. The study had taken the help of different use cases in rural, semi-urban, and urban contexts. The main findings in the study highlight that in addition to helping increase physical capacity in the healthcare sector, modern technological innovations can help raise the operational and quality key performance indicators such as patient/bed turnover, reduction in medical errors, minimizing medication errors, reducing adverse drug reactions, facilitating infrastructure development, optimizing bed occupancy rates, increased use of medical equipment, reduction in patient wait times, enhancing doctor/staff to patient ratio, etc. Besides, honing healthcare standards through improved technology further helps in creating employment opportunities that have potential benefits for the healthcare sector and the economy. For instance, advances in genomic sequencing, vaccine and pharmaceutical development, and AI have made considerable contributions to improving patient care. Connected medical devices are creating new opportunities that were hitherto not possible.

Despite these advantages, healthcare organizations need to be selective in which technology to invest in, which should be based on a careful assessment of the fit of the technologies to the specific needs and strategies of each healthcare organization.

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Annexures

Annexure I

LIST OF HEALTHCARE ORGANIZATIONS USING LATEST TECHNOLOGIES

Name of The Company	Year Founded	Company Type	Product Innovation	Process Innovation	Business Innovation	Current Technologies Used
Sankara Nethralaya	1978	Established		Mobile Eye Surgical Unit (MESU)		Teleophthalmology, Femto LASIK, Wavefront Tech,
Fortis Malar Hospital	1992	Established	PACS Model			Extra Corporeal Membrane Oxygenation (ECMO), Ventricular Assist Device (VAD) Destination Therapy, Stasis, and Google Analytics
Columbia Asia Hospital	1996	Established		SilentScan package with Signa Pioneer 3T system, Ambient Experience Tech Package		Artificial Intelligence (AI), Predictive Analytics, Telemonitoring & Teleradiology, and Fusion Imaging
Saifee Hospital	2005	Established	Chektrust Pal (CTPAL)			Robotic Surgery System, Aqua-Zero Technology, and Thulium Fiber Laser (TFL)
Aditya Birla Memorial	2006	Established			Doorstep healthcare service	Assisted Reproductive Technologies (ART) services, Flow Cytometry, and Immunofluorescent Microscopy
Fortis Memorial Research Institute	1996	Established		Indigenously Developed Technique for Total Body Irradiation		Tesla Digital MRI, Stem Cell, E-ICU, Bi- Plane Cath Lab, Voice Modulated & Integrated Operating rooms
Continental Hospitals	2013	Established			Public–private partnership, Infrastructure model, and clinical model	Apheresis, Electromyography (EMG), Nerve Conduction Velocity (NCV)

Name of The Company	Year Founded	Company Type	Product Innovation	Process Innovation	Business Innovation	Current Technologies Used
Omega Hospitals	2010	Established	Latest state-of-the-art technologies including cancer radioactive iodine treatment and the most modern positron emission tomography treatment			VMAT Radiation technology, Robotic Cyberknife VSI, 3D Digital Mammography with Breast Tomosynthesis, and Dual Head Spect Gamma Camera
Nanavati Hospital	1951	Established			TC4A (Tech Care for All) with a spectrum of clients, offers data-rich, clinically validated, and customized Telemedicine and frugal EMR platforms	Telemedicine, Cathlab, 3D C-arm, and Neuro Navigation
SigTuple	2015	Start-up	AI100 with PBS Analyzer, Sharav Analyzer for in-vitro diagnostic use			Automated digital microscope and AI platform
Mocxa Health Pvt Ltd	2018	Start-up		A unique video-based epilepsy diagnosis model		360EVS and 360DID
Gibbr Technologies Pvt Ltd	2015	Start-up				Deep learning algorithms, Deep neural Network (AI algorithms)
Bioscan Research	2017	Start-up		Designed a self-aligning mechanism that is automatic and passive and works seamlessly in real-time to ensure the alignment of the probe automatically at a predefined angle to any irregular surface		Artificial Intelligence (Machine Learning) and 360DID

(Continued)

Name of The Company	Year Founded	Company Type	Product Innovation	Process Innovation	Business Innovation	Current Technologies Used
FLUID AI	2012	Established	Augmented Reality (AR) is a part of the artificial intelligence, facilitating an environment where the customer can interact with the technology by virtually putting the customer onto the screen.			Artificial Intelligence
Wellthy Therapeutic	2015	Start-up		Longitudinal interrupted time series (ITS) analysis, Wellthy CARE™ Digital Therapeutic platform (WDTx)		Digital Therapeutics (Artificial Intelligence)
AROGYA.AI	2019	Start-up	NA	NA	NA	Artificial Intelligence and SAAS (Software as a service)
BrainSight Technology Pvt Ltd	2019	Start-up	VoxelBox platform makes fMRI analysis readily accessible to clinical practitioners for investigating brain related ailments			Artificial Intelligence and FMRI
Cloudphysician	2017	Start-up		Smart ICU Solutions (Tele-ICU Care)		RADAR (Radio Detection and Ranging)
iKure TechSoft Pvt Ltd	2010	Start-up		WHIMS (Wireless Health Incident Monitoring Service)		Hub and Spoke Model, AI
LVPEI	1987	Established			Momentum model and innovative pyramidal model of delivery	Image Analysis, AOSLO, and Eyesmart EMR
Fernandez Hospital	1948	Established				Telehealth

Name of The Company	Year Founded	Company Type	Product Innovation	Process Innovation	Business Innovation	Current Technologies Used
Medanta	2008	Established	e-clinic model			3.0 Tesla MRI, Gamma Camera, MRI-guided vacuum-assisted breast biopsy, and DEXA Scan
Max Healthcare	2001	Established		Patient Apps		Radius-7, Brain Suite Intra Operative Imaging, Cataract Suite, and CyberKnife
PierianDX	2016	Start-up		Innovative genomics sequencing processing platform		Genomic Analytics
Applied PilotFish Healthcare Integration	2001	Established		Integrate engine solution to meet the needs of healthcare entity		APIXL- PilotFish
Ambir Technology	2001	Established	NA	NA	NA	Digital scanners and Athena Health
Neurosynaptic Communications Private Ltd	2002	Established		Telemedicine Solutions		Myremedi, Remedi and Remedi nova devices
Vimta Labs	1984	Established		CGMP Laboratory Services/ Analytical services		Biopharma
NATCO PHARMA Ltd	1981	Established	Innovation in pharmaceutical R&D			Analytical R&D caters to API
Pfizer Ltd	1849	Established	Biotechnology Innovation			3D-MAMMOGRAPHY, AI, and Machine Learning in Pharmaceutical Research
Bharat Biotech	1996	Established	Innovative technology in vaccine development			Biogit, Regen D-150
Biocon Ltd	1978	Established		Digital innovation and value creation		CANMAb™, Insulin Glargine pen
Transgene Biotek Ltd	1991	Established	Technologies to improve the lives of those suffering from cancer through novel drug innovations			NA
Thyrocare Technologies Ltd	1996	Established	Automated diagnostic laboratory			ELISA

(*Continued*)

Name of The Company	Year Founded	Company Type	Product Innovation	Process Innovation	Business Innovation	Current Technologies Used
CitiusTech	2005	Established		Technology service and provides solution to hospitals and provides digital technology services like cloud computing		BI-Clinical, Data and Analytics
Birlamedisoft Pvt Ltd	2001	Established		Provides digital and information technology consulting, services, and solutions to hospitals		PACS software and HIMA software
KareXpert	2018	Start-up		Digital healthcare platform, smart healthcare provider to hospitals		EMR and HER, NDHM Integration
Infoline Technologies Pvt Ltd	2001	Established	NA	NA	NA	ILifeHIS, ILifeLIS
Caresoft Consultancy	2007	Established		Cloud enabled mobile app		HIS (Hospital Information System), Online digital chart, and BI tools
Forus Health	2010	Established			Bring down the cost of diagnosis	Telemedicine
Oncosystem	2011	Established		Innovative prognostic and predictive solutions for various types of cancer		Artificial Intelligence
SoftLink International	1997	Established		Focused on Healthcare IT solutions)		HIS (Hospital Information System)
Syscon Infotech	1998	Established		Focus on customer driven solutions like CRP software		E-BUSINESS SOLUTION, Enterprise App Integration
Tricog	2014	Start-up		AI powered solution		ECG Diagnosis with AI-Powered Solution
Swasthya Slate	2014	Start-up		Mobile health technology able to perform 33 diagnostic tests		Mobile App

Name of The Company	Year Founded	Company Type	Product Innovation	Process Innovation	Business Innovation	Current Technologies Used
S10 Technologies	2011	Start-up		Cloud based appointment booking platform and a practice management platform for doctors		S10 Health app
MedOnGo	2014	Start-up		Web and mobile based healthcare portal		MedOnGo Healthcare Provider app
Blooray	2006	Established		IT Solutions specialized provider of Medical Automation Software		MeDic Software
Avengersoft	2012	Start-up		Information Technology Services to Healthcare industry		Dentsoftware
Medtronic	1949	Established	First external and battery-operated pacemaker			Cardiovascular implantable electronic device (CIED)
Vision RX Lab	1959	Established	Offers complete lenses solution			Satin Klear UV, Nova UHD
Comofi Medtech	2018	Start-up		Robotic surgery focused on innovation		AI, NT-Mask, IoT technologies
Abbott	1888	Established	Developed first HIV blood screening test			Pro Vascular Self-Expanding Stent System,Abbot prism director
Johnson & Johnson	1886	Established	Developed Medical Devices			Intelligence-based call routing and auto answer
Aum Medtech	2009	Established	NA	NA	NA	Wifi-enabled video laryngoscope and Intelligent AUM Android app
OPDLift	2019	Start-up		Offers telemedicine and online consultation		Automatic follow-up booking and Telemedicine
Nutritantrums	2020	Start-up	NA	NA	NA	Apps help to track the diet records
Aarca Research	2019	Start-up		Noninvasive Health screenings		IHRA AI technology and FDA-cleared thermal camera

(*Continued*)

Name of The Company	Year Founded	Company Type	Product Innovation	Process Innovation	Business Innovation	Current Technologies Used
Gynoveda	2018	Start-up		Technology to develop self-care solution		Artificial Intelligence
Oswald Labs	2016	Start-up	Disabled friendly website			Augmenta11y App
Credihealth	2013	Start-up		Tele / video health consultation		Telemedicine
Cure.fit	2016	Start-up			Workout routines designed	Artificial Intelligence
Cognate Health Services	2017	Start-up			Deliver customized wellness programs at affordable rates	Teleconsultations
PharmEasy	2014	Start-up		Provides online pharmacy		Teleconsultations
MFine	2017	Start-up		Online doctor consultations		Artificial Intelligence
Qure.ai	2016	Start-up			Artificial Intelligence	Qxr-AL algorithm and Q-Track-One stop solution
TerraBlue	1998	Established				Xaant – medical diagnostic device for the automatic identification
Strand Life Sciences	2000	Established		Provides bioinformatics solutions		Genome Browser, Avadis, and Sarchitect
EyeNetra	2011	Established	Prescription VR (Virtual Reality) screens, Autorefractors, Digital lensometer			Smart phone-powered refraction
Advancells	2013	Start-up		Provides therapeutic applications of Regenerative Medicine		Stem cell technology
Glocal Healthcare	2010	Established		Provides teleconsultation and telemedicine to rural area		Digital Dispensaries
Apollo Hospitals	1983	Established		Noninvasive method to conduct health screening		Robotic surgery and artificial intelligence
Narayana Health	2000	Established	IPIHD Innovator for cardiac			Data analytics and Artificial Intelligence

Annexure II

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Annexure III

Case Study

KARMA HEALTHCARE: WAY FORWARD

The case provides an overview of the Karma Primary Healthcare's origin and growth during the period 2014–2021 and the unfolding growth opportunities, many of which opened up consequent to the COVID-19 pandemic that took the world by storm in March 2020. Karma was founded by Jagdeep Gambhir, an alumnus of the Indian School of Business, to deliver quality healthcare to communities in rural India. As of 2021, Karma clinics were located at 25 locations in semi-urban and rural India; nurses at these clinics used a teleconsultation-based care model to connect patients with remotely located doctors. The case suggests that Karma has been reasonably successful in making progress toward its original mandate of delivering care to rural communities; however, opportunities for further growth existed. The case presents the opportunity to grow the organization's nascent B2B business, given the broad acceptance and high demand for teleconsultation-based care models across India during and after COVID-19. Furthermore, the case discusses in detail the opportunity for Karma to enter the urban teleconsultation-based healthcare market given Karma's experience and capabilities and touches upon several factors that would be critical for making the decision to enter this market.

The case touches upon important healthcare concepts, including challenges in delivering healthcare, especially primary care, in rural India, entrepreneurship in the healthcare context, telemedicine as a solution for addressing the healthcare needs of rural areas, emerging digital start-ups in India, the phenomenon of disappearing "family physician model," adaptation of healthcare models to address changing contexts (including highlighting the glaring disparities in healthcare quality and access between rural and urban areas), etc. The case also introduces the notions of healthcare management, innovation and entrepreneurship, healthcare in emerging markets, and technology in the healthcare industry.

Annexure IV

Profiles of Team Members

Principal Investigator I **Prof. D.V.R. Seshadri** Clinical Professor of Marketing and Director of ISB-Centre for Business Markets (Hyderabad) Since 2000 until joining ISB in 2016, **Prof. D.V.R. Seshadri** taught at various IIMs (particularly at Bangalore, Ahmedabad, and Udaipur). For 15 years prior to 2000, he worked in a variety of companies (public sector, family business, and entrepreneurial start-ups, the last 10 of them as CEO), spanning a variety of industries (petroleum refining and petrochemicals, bulk drugs, active pharmaceutical ingredients, precision manufacturing, and software). His areas of interest, among others, include: B2B Marketing, Innovation, and Entrepreneurship & Intrapreneurship and Strategy. He is actively involved with several NGOs such as Aravind Eye Care Systems, Madurai and DHAN Foundation, Madurai, in addition to engagement with several top corporates such as companies of the Tata Group and L&T. He has been engaged in teaching/consulting capacities with over 100 large corporates, both India-based and foreign MNCs. He has coauthored several books and over 100 case studies and authored several application-oriented journal articles in his areas of interest.	
Principal Investigator II **Prof. Madhu Viswanathan** Senior Assistant Professor of Marketing & Research Director, Indian School of Business (Hyderabad) Prof. Madhu Viswanathan is a Senior Assistant Professor of Marketing at the Indian School of Business (ISB). Prior to joining ISB, he worked as an assistant professor at the University of Arizona. Professor Viswanathan's research work focuses on the role of distribution channels, B2B relationships, salesforce compensation, and its impact on marketing mix elements like prices and assortments. His work has been published in the *Journal of Marketing Research*, a premier journal in marketing. He has consulted and worked with companies spanning a wide range of industries, including retail, insurance, and healthcare. Prof. Viswanathan received his PhD from the University of Minnesota, Twin Cities, and his undergraduate from BITS, Pilani.	

Mrs. Ratna Geetika

Research Manager, ISB-Centre for Business Markets (Hyderabad)

Mrs. Ratna Geetika is a Research Associate at the Centre for Business Markets, Indian School of Business (ISB). She holds an MA and MPhil in Economics from the University of Hyderabad, Hyderabad. She has over 12 years of experience in the education field and has been involved in various research projects.

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