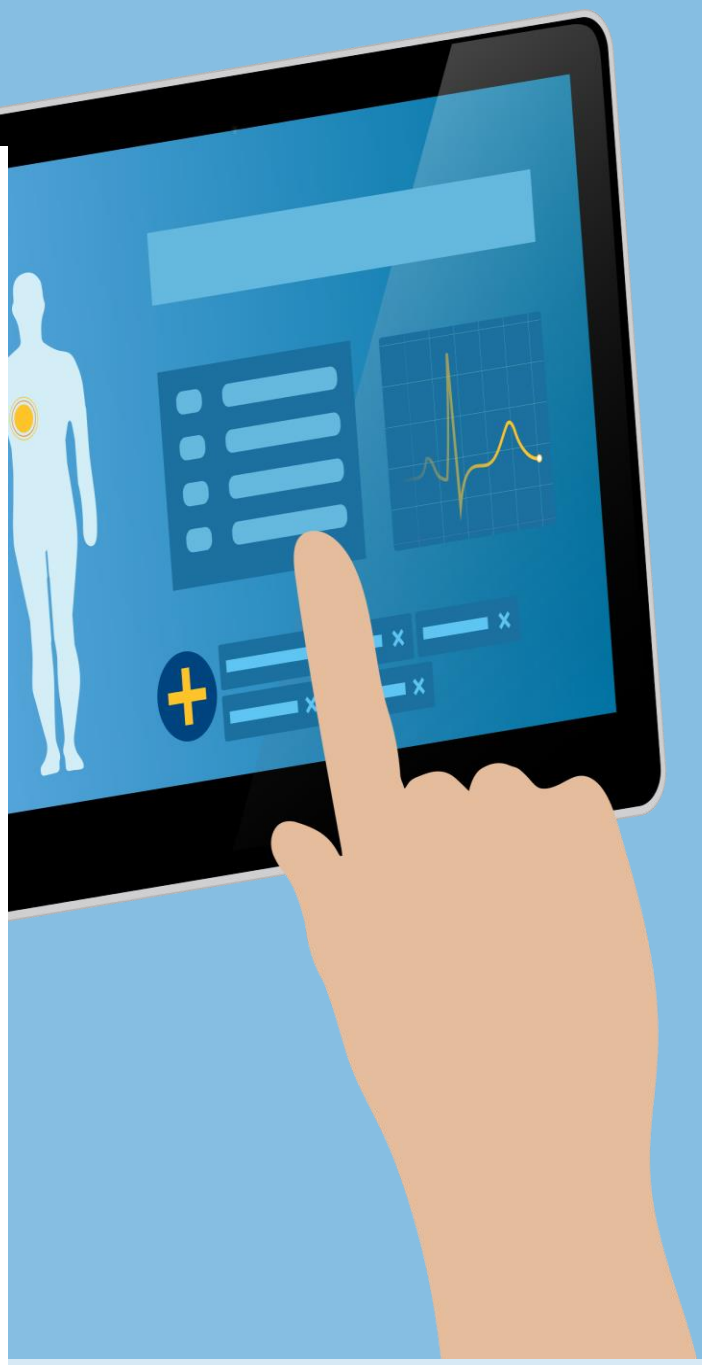
Digital Health in India



Krishnan Narayanan

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FICCI

itihaasa
Research and Digital

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I. Foreword

We are delighted to present this important report on “Digital Health in India”, prepared along with our knowledge partner, itihaasa Research and Digital, as part of the FICCI Summit and Exhibition on DT5 – Digital Transformation Series 5 on Healthcare Technologies, Healthcare Transformation and the emerging opportunities.

Indian healthcare is one of the fastest growing sectors, and is expected to reach USD 300bn by 2022. Much of this growth can be attributed to digital & innovation powering inclusion, improving affordability and enabling qualitative care with key insights coming out of medical devices and software applications using Artificial Intelligence, Machine Learning, Analytics, 3D sensing, Blockchain, AR/VR, IOT and inclusion facilitated by Tele medicine, Remote Diagnostics and Wearables. With the advent of 5G in the horizon, healthcare will get into a new orbit with more and more of prediction and proactive detection.

Covid19 has brought a huge focus on our healthcare system, highlighting its strengths with digitalization, showcasing potential opportunities and exposing areas to improve. The 3 golden vectors of healthcare such as Access, Cost and Quality need extensive discussions. While very few would have ever imagined that doctors would like to see patients remotely / digitally and make the diagnosis in the pre-Covid-19 world, it has become the defacto norm process in the current Covid scenario. Several start-ups have produced innovations, in terms of ventilators, oxygen concentrators and other low cost medical devices. Processes like ISO 60601 for assessment/certification of medical products, ISO 13485 for medical devices, ICEEx have become the need of the hour. Global players outsourcing to India around healthcare and life sciences have also risen tremendously.

The crisis that has emerged due to COVID-19 is unprecedented, but in this battle, we not only need to protect ourselves but also have to keep moving forward. Our Prime Minister Shri.Narendra Modiji has given a clarion call to be a Self-reliant India. In line with the call, FICCI has launched “FICCI for Start-ups” as a national initiative to support the start-ups & innovation in a 360-degree manner with funding, mentoring and

market reach. The FICCI TNSC Technology Panel has also been closely working with the Tamil Nadu Govt on various areas including e-Governance, E-commerce, Digital Transformation, Start-up ecosystem and Cyber security in not only engaging with citizens, industries and institutions through various conferences, roundtables and surveys but also has played a key role in providing key inputs for shaping various policies.

We are focusing on how digital technologies are transforming the healthcare ecosystem and creating opportunities There is an urgent need to enable Tech & Medical pillars to showcase, deliberate, and explore the latest technologies, opportunities, & innovations shaping healthcare systems. We present this conference in this context. We want to thank the 2 countries Estonia and Israel for joining hands with FICCI to become country partners to this International Summit and about 20 industry bodies & institutions that are supporting this conference by sending delegates and exhibitors. We also take this opportunity to thank CapitaLand for coming forward to sponsor and support this DT5 conference.

We wish the very best for the conference and an insightful day ahead (June 4, 2021) with lot of takeaways for you and your organization, in taking the leap into the new future by creating a self-reliant India powered by Innovation, creation of jobs, a maker for the world mindset which leads to rapid economic growth which puts India firmly on the path towards a $5tn economy by 2025.

Dr. G S K Velu

Chairman

FICCI Tamil Nadu State Council

Dr. Rajaram Venkataraman

Convenor

FICCI TNSC Technology Panel

II. Preface

I am delighted to author the report on 'Digital Health in India'. This is an important topic, and is aligned with our work at itihaasa Research and Digital and of personal interest.

We set-up itihaasa (www.itihaasa.com) as a not-for-profit research organization that studies evolution of technology domains in India. We study domains like Information Technology (see our chronicle on the history of Indian IT), Artificial Intelligence and Brain Sciences (see our research landscape studies), Digital Transformation (see our reports on digital in the new normal). Our research in AI, data governance, and digital have intersected with the healthcare domain and given us some new perspectives.

At a time when all of us have been touched by the effects of the ongoing pandemic, each of us has strongly felt the importance of good quality healthcare in our lives. We have experienced 'digital health' is some way or the other – whether it was while checking how widespread Covid was in our neighbourhoods on AarogyaSetu, or while booking a vaccination slot on CoWin, or doing a teleconsultation with a doctor from the comforts of our home. I am also happy to write about this topic, especially after having started my career in the consumer healthcare space.

I am thankful to FICCI for inviting me to author this report. I am also thankful to the healthcare business leaders who shared their insights and perspectives with me for the report.

I hope this report gives you a good insight into the direction of the digital health journey in India.

Krishnan Narayanan

Cofounder and President

itihaasa Research and Digital

1. A medical story from the not-so-distant future

Digital health in action in rural India

Ravi and Selvi, residents of the Acharavakkam village in Chengalpattu, Tamil Nadu, are expecting their first child. Selvi has had a smooth journey so far into her second trimester, feeling comforted and thrilled with her baby's movement inside her. That morning though, she wakes up feeling bad – with a severe headache and a shooting pain in her stomach. She is feeling jittery.

Their nearest hospital, the Chengalpattu Government Hospital, is over 25 kilometres away. But they don't have to travel all the way there. She logs into the eSanjeevani Hospital App on her mobile phone and fixes a time with her doctor. He does an online consultation and recommends rest and some home care routines, and tells her to come in to the hospital later for an ultra-sound. Selvi feels somewhat reassured.

That weekend, she visits the hospital for the scans. At the registration desk, there is a QR code – she whips her smartphone, launches her personal health record app and scans the code. The hospital receives all her details based on her unique health ID. She is registered for her medical visit in an instant.

Looking at her reports, her doctor decides to consult a senior gynaecologist in Chennai. He logs into the tele-consult portal for a second opinion. Selvi gets a request from the Chennai hospital seeking permission to see her medical records stored in her Medi-locker on the cloud, and she approves it.

The situation is serious but addressable. It is good that they consulted in time. The Chennai doctor analyses Selvi's medical scans using her AI system, does a quick diagnosis, and recommends a suitable treatment and diet plan. Selvi's Medi-locker is updated with the diagnosis summary from the Chennai doctor.

Based on the e-prescription provided by the doctor, Selvi is able to order her medicines online. The e-pharmacy startup delivers her medicines that evening. In her mobile app, alerts have been set based on the medical advice.

Three months later, Selvi checks into the hospital for the delivery. She approves a request from her medical insurance provider seeking her consent for accessing her hospital / medical records. Her claim is approved instantly and payment transferred online.

Ravi and Selvi are now proud parents of a healthy baby girl. Selvi searches online for a good paediatrician….

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If you think that this scenario is impossible in India, think again. If you think that this will play out in real life only after several more decades, think again. The futuristic setting described may appear to be in sharp contrast to current grim realities of healthcare that we are experiencing in India in the wake of the COVID-19 pandemic. But the wheels of digital transformation of healthcare have started turning. And the pandemic has catalysed the adoption of digital technologies into our everyday lives, including how we consume health services.

First, let us look at how this pandemic-induced medical digital-transformation has played out across the world.

2. The pandemic catalyses adoption of digital health worldwide

In public health response, healthcare diagnosis and provision

The COVID-19 pandemic has significantly impacted the entire world. It has forced governments, businesses and the people to adopt digital technologies in a big way, to stay connected and consume different essential services. Healthcare is no different.

2.1. Digital health initiatives globally during the pandemic

Digital technologies are being harnessed to support public-health response and in medical diagnosis and provision of healthcare services. See figure below.

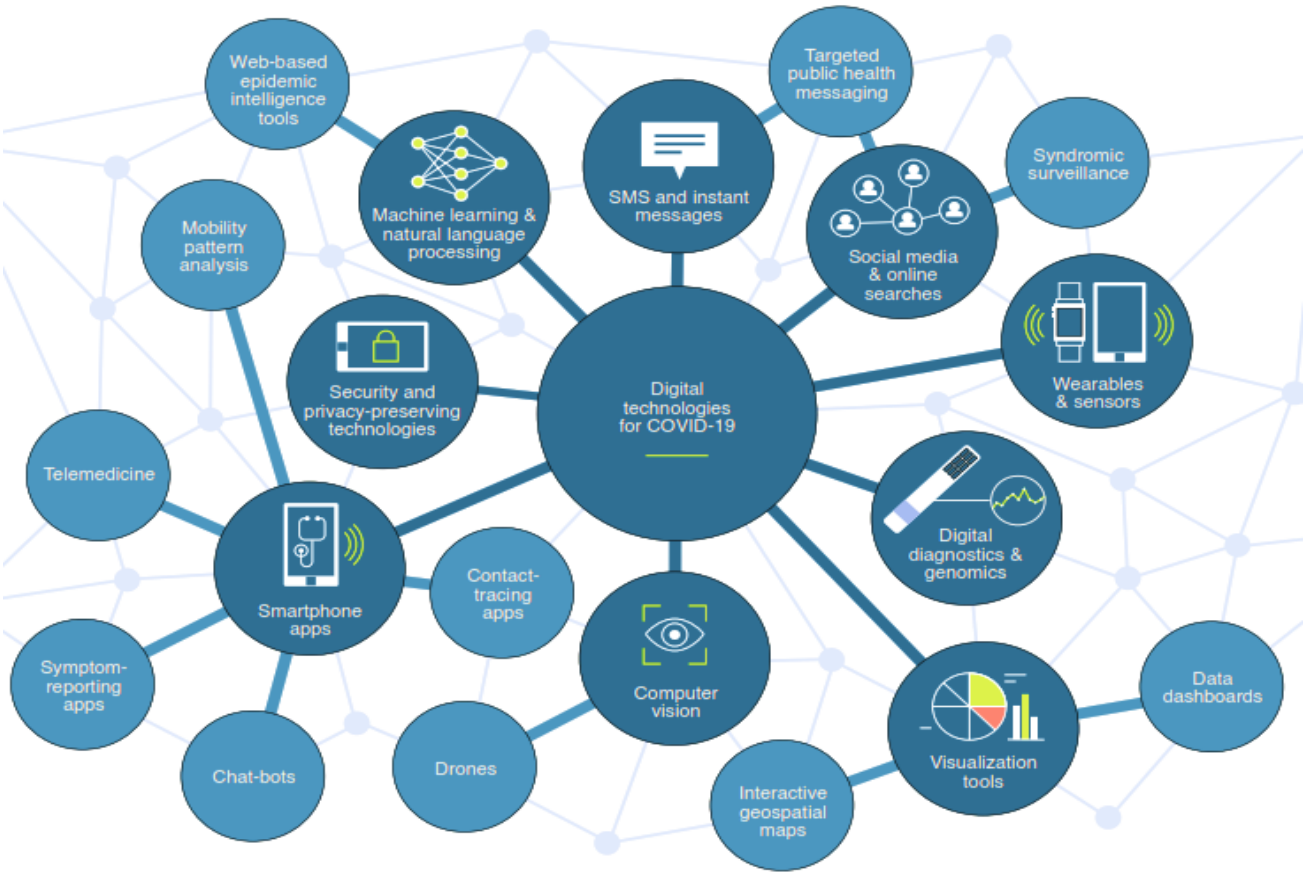

Fig 1: Digital Technologies for Covid-19
Source: Nature Medicine

Governments are conducting epidemiological surveillance, case identification and contact tracing, and predicting the waves of infection in specific geographies. They are making use of telecommunication technologies, advanced data analytics and machine learning, and data visualization techniques for these purposes. They are making use of social-media platforms for public communications.[1] The pandemic forcefully brought out the need for national IT infrastructure – to generate accurate and real-time estimates of disease incidence which will help in efficient allocation of scarce medical resources, and to track, trace, and quarantine affected individuals during times of public health emergencies.[2]

One study finds that healthcare providers are leveraging clinical informatics to COVID-19 response, mostly for projects like telemedicine, which includes training providers on existing telehealth tools and building new workflows for video triage of COVID-19 patients, and reporting and analytics, which includes creating dashboards and developing digital contact tracing tools.[3]

Innovative digital health solutions for Covid-19 diagnosis are emerging, especially by leveraging AI and information from wearable IoT devices. Some examples include cough recordings for diagnosis with 98% sensitivity and 94% specificity, pre-symptomatic detection from highly elevated heart rate from smartwatch data, and SARS-CoV-2 detection with CRISPR-Cas13a and mobile phone.[4] Examples of AI in action include solutions from Babylon Health and its symptom-checking app with a specific COVID-19 decision algorithm, and a deep-learning neural network solution to analyse chest X-rays, identify and distinguish COVID-19 from other forms of pneumonia.[5]

2.2. Digital health initiatives in India during the pandemic

In India too, several initiatives have come up for developing epidemiological model for COVID-19 – like the Department of Science and Technology initiated COVID -19 Indian National Supermodel coordinated by JNCASR and IISc, the SUTRA model by professors from IIT Kanpur and IIT Hyderabad, and the Indian Scientists' Response to COVID-19 group's INDSCI-SIM model. These models monitor / predict the future transmission of

infection, and provide inputs to Indian policy makers to evaluate interventions like imposing lockdowns, quarantines, and enhanced testing.

A number of initiatives were undertaken by Indian researchers to detect the disease. ISI Kolkata researchers developed Deep Learning tool for COVID-19 screening. DRDO's Centre for Artificial Intelligence & Robotics (CAIR) developed ATMAN AI, an AI-based-COVID detection application software using chest X-rays (CXRs) which can classify the images into normal, COVID-19 and pneumonia classes.[6]

The Government has created AarogyaSetu, a contact tracing app to track people with the COVID-19 illness and the people they come in contact. In just over a month after its release, 114 million users downloaded the app. It proved effective – amongst those who were recommended for testing for COVID19, almost 24% tested positive, as compared to the overall COVID19 positive rate of around 5% (in May 2020).[7] For the vaccination drive, the digital app / portal CoWin has been created.

The Health Ministry launched the e-Sanjeevani platform in April 2020, which completed over three lakh consultations in a short span of six months. Private healthcare providers too have embraced telemedicine in a big way. For instance, the Apollo Hospitals has launched its telehealth program 'Apollo 24/7'. A number of innovative startups with innovative digital health solutions have also emerged – Nocca Robotics, an IIT Kanpur-incubated company developed Noccarc V310, a fully-functioning ICU ventilator. Modulus Housing an IIT Madras incubated startup developed a quickly installable portable hospital unit.

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We will examine these digital health initiatives in India in greater detail later. But, let us turn our attention first to the current state of healthcare in India, to understand the context in which this digital transformation is being envisaged and taking place

3. Current state of healthcare in India

A complex system facing many challenges

Providing healthcare to 1.4 billion people is not an easy task. Over the decades, India has shown improvements in parameters like life expectancy and healthy life, decreases in parameters like maternal mortality rate and infant mortality rate, a reduction of disease prevalence / incidence. On the parameter of Universal Health Coverage (UHC), which involves all people receiving the health services they need, of high quality, without experiencing financial hardship, India has progressed in the last three decades – the UHC index value has increased from 27 (1990) to 42 (2010) to 47 (2019).[8]

But India needs to improve on all these parameters substantially. Take UHC for instance – in a study that mapped 23 health coverage indicators in 204 countries worldwide, in 2019, India's UHC score (47) was below the world average (60), where country-wide scores spanned from 95 or higher in Japan and Iceland to lower than 25 in Somalia and the Central African Republic.[9]

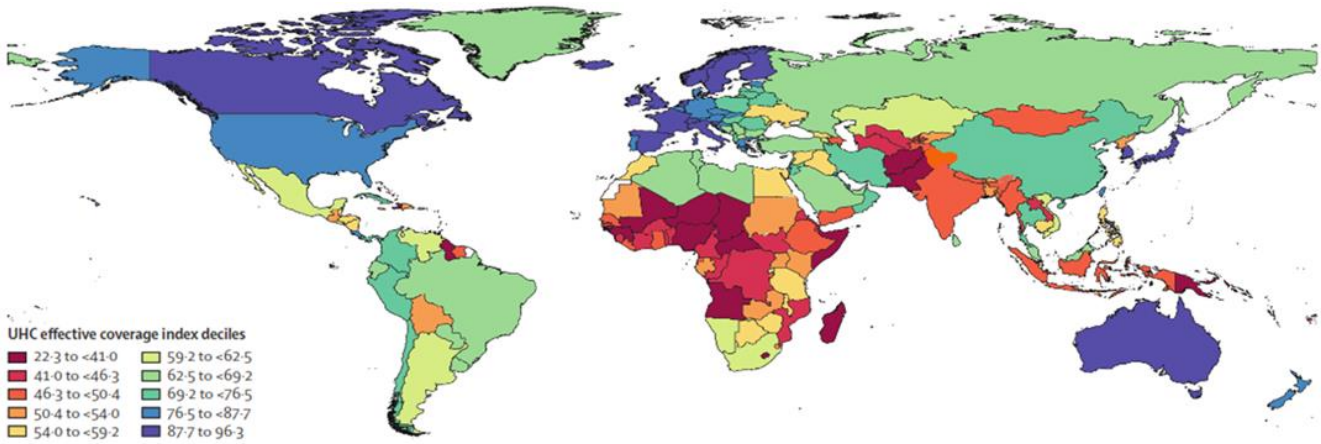

Fig 2: Universal Health Coverage (UHC) across the world
Source: Adapted from 'The Lancet'

Indian healthcare suffers from the following key challenges:

1. Lack of resources
2. Skewed access and variable quality
3. Affordability of healthcare

3.1. Lack of resources

Between FY15-FY21, India's public health expenditure as a percentage of GDP ranged from 1.2% to 1.8%. India's National Health Policy (2017) aims to increase Government spending on health to 2.5% of GDP by 2025.

But these investments are extremely low, given our country's size and other growth parameters. India's public expenditure on health as percentage of the GDP is lower than countries classified as the "poorest" in the world. Even the 2.5% projection in 2025 is much lower than the expected global average of 6%.[10]

The lower investment translates into lower availability of doctors and other allied healthcare professionals. India currently has for 1000 people, 1.3 hospital beds, 0.65 physicians (the World Health Organisation standard is 1 per 1,000 people) and 1.3 nurses.

India will therefore need to substantially increase the numbers of trained health personnel across various categories to achieve a ratio of at least 2.5 doctors and 5 nurses per 1,000 people by 2034. ***(Source: NITI Aayog)***

3.2. Skewed access and variable quality

In addition to the per-capita availability of healthcare professionals being low, India also suffers from a skewed distribution of these resources. It has a geo-concentration biased towards urban areas and specific states in the country.

Around 65% of hospital beds in India cater to almost 50% of the population concentrated in Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, Telangana, West Bengal and Kerala.

The other 50% of the country's population living in the remaining 21 States and 8 Union Territories has access to only 35% of hospital beds.

A study on health workforce in India, based on the 2001 Census data, shows the following composition of health workers – 40% doctors, 31% nurses and 29% ancillary health professionals and traditional / faith healers. Of all health workers, 59% are in urban areas (where 28% of the population resides) and 41% are in rural areas (where 72% of the population resides).[11] The ratio is even more skewed when we compare only the doctors and nurses.

In India the density of doctors and nurses in urban areas was 4 times that in rural areas.

The quality is variable. Not everyone who claims to be a doctor has the requisite qualifications, especially in rural India. One study (*Two Indias*) conducted across 1519 villages across 19 Indian states finds that most providers (86%) are in the private sector, and in terms of qualifications, 68% were informal providers, 24% AYUSH providers 8% had an MBBS degree. Thus, 68% of the 'doctors' in villages have no formal medical training.[12]

From a medical supply chain point of view too, the distribution is skewed – India imports nearly 86% of its medical devices and imports 80% of its API (Active Pharmaceutical Ingredient) from China. ***(Source: NITI Aayog)***

3.3. Affordability of healthcare

In India, healthcare expenditure is predominantly an out-of-pocket-spending, not covered by insurance or free medical coverage. Studies show such expenditure is as high as 62% (see figure below) and likely to remain high even in the future.[13] This puts enormous financial strain on individuals – the poor are unable to afford healthcare, and the financially vulnerable fall into poverty at the incidence of a medical episode.

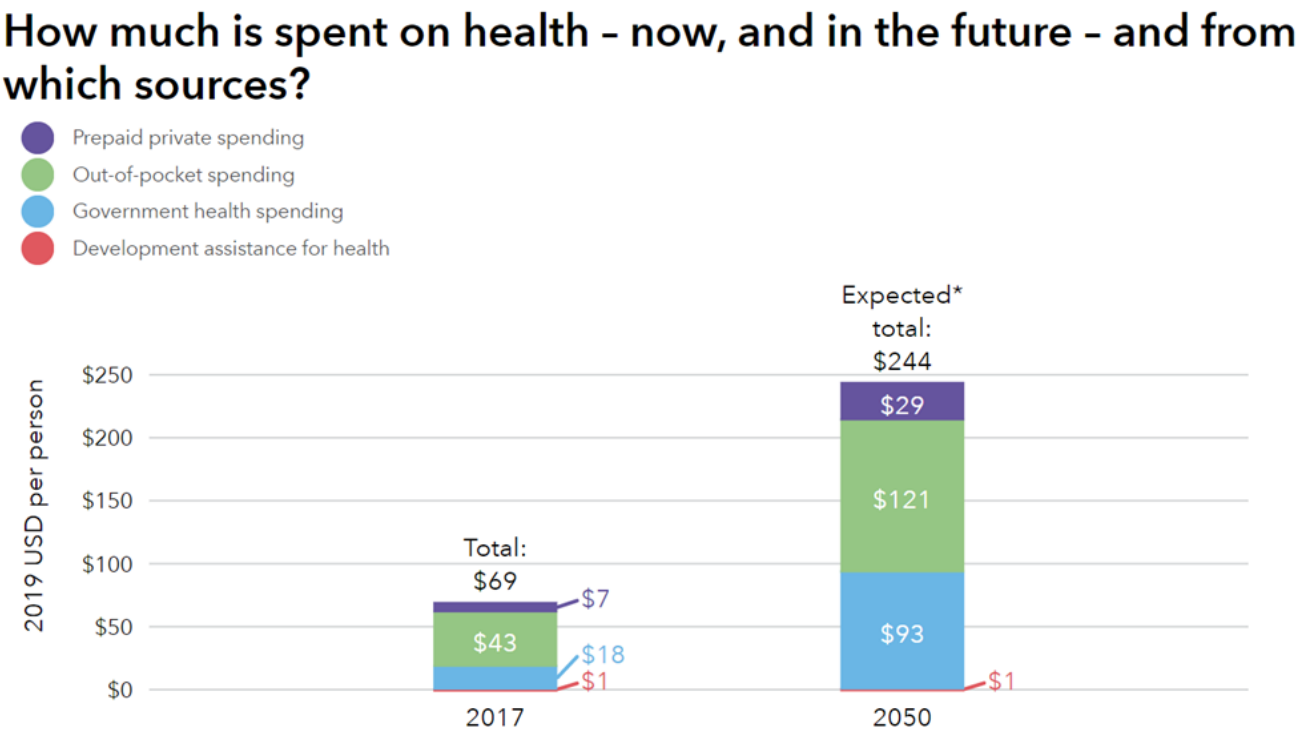

Fig 3: Health expenditure – How much is out-of-pocket spending?
Source: Financing Global Health Database 2019

Given the skewed distribution of healthcare resources in India, people often have to travel far to get quality medical services, thus adding to their financial burden.

India is divided into two nations not just by quality of health care providers, but also by costs – states providing higher healthcare quality, do so at lower per-visit costs. ***(Source: Two Indias study)***

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One of the ways to address these healthcare challenges is through the adoption of digital health, whose relevance and prominence has been slowly and steadily rising in India. Both the government and the private sector have undertaken a number of digital initiatives over the years. The significant adoption of digital systems in other areas in India (such as identity, payments, etc.) along with a new vision for the digital healthcare system in the country in recent years, offer some hope.

4. Future of digital health in India

On the backbone of a digital infrastructure and health ecosystem

Let us examine the possibilities for digital health along these four perspectives.

1. National digital health ecosystem
2. Telemedicine
3. Startups and healthcare innovations
4. Digital medical education, new healthcare models and regulations

4.1. National digital health ecosystem

The government's vision for creating a national digital ecosystem is articulated in the 2017 National Health Policy. The National Digital Health Blueprint lays out an architectural framework for a national health stack and digital health in India. In August 2020, the Prime Minister announced the launch of the National Digital Health Mission that aims to create an "open digital health ecosystem" (health ODE).

> ***"Health has also been identified in Budget 2021-22 as one of the six main pillars to drive growth. The main objective of Pradhan Mantri Aatma Nirbhar Swaasthya Yojana is to strengthen health systems across continuum of care to meet challenges of current and future pandemics along with expanding & building robust IT enabled surveillance systems to track and contain the spread of diseases."***
>
> - ***Dr Harsh Vardhan, Union Minister for Health and Family Welfare on 'Indian Health system expansion in post-COVID era'***
>
> ***(Source: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1707848)***

This will be a shared digital infrastructure, like the Unified Health Interface, that will be leveraged by both public and private enterprises to build and provide innovative healthcare solutions. The key building blocks of this digital stack include standardized health registries of doctors and healthcare facilities like hospitals and diagnostic centres, a unique patient Identity (Health ID), and federated health records (PHR and eMR). See Fig 4.

At the national level, the DigiDoctor, Health ID, Facility Directory, Data Exchange, and Consent Manager systems will be set up. These will be working through the Health cloud. At the State level, the e-Hospital system, along with EHR repositories and federated registries, is available. At a facility level, the e-Health Card, PHR web viewer and EMR web app will be available.[14] The medical story in Chapter 1 will be realised with the help of this digital health stack.

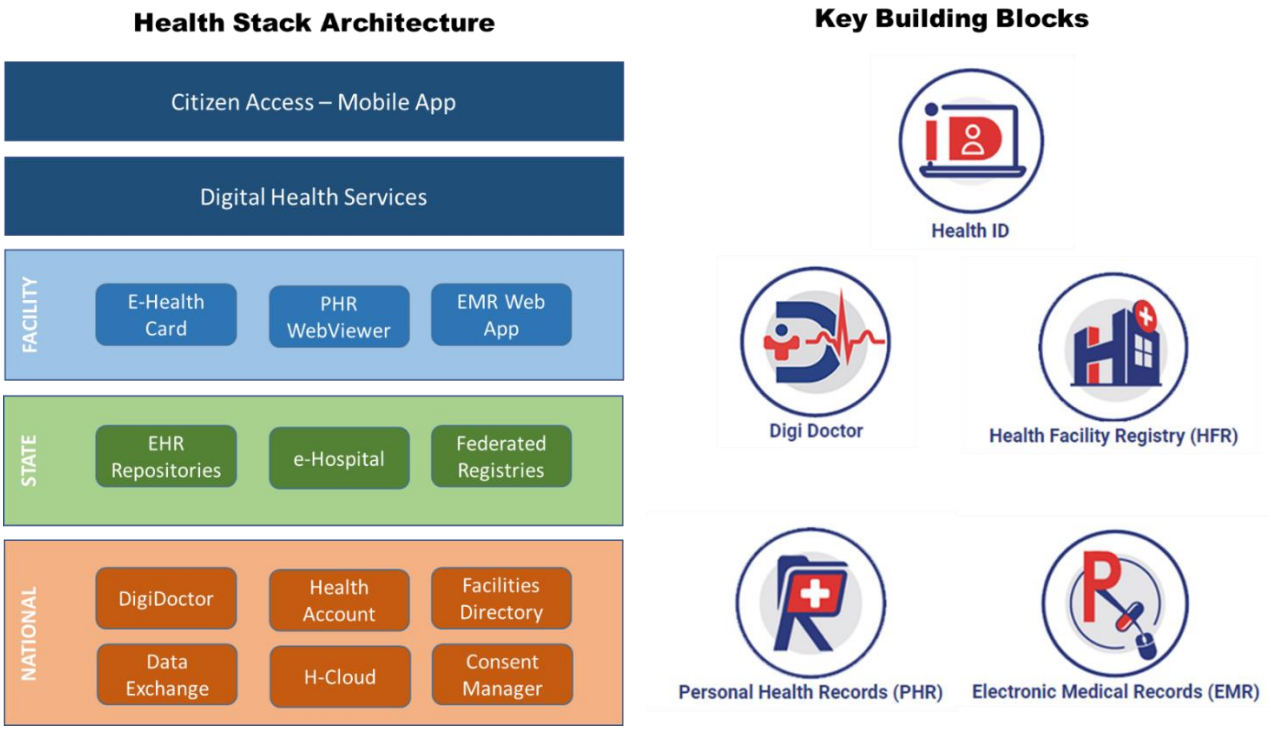


Fig 4: Digital Health Stack and Key Building Blocks
Source: National Digital Health Mission and MOHFW

A FICCI – BCG report articulates five themes of the national digital health ecosystem that will drive healthcare transformation in India – 1) Information transparency 2) Interoperability 3) Standardized claim processing 4) Prescription digitization 5) Playground for innovations.[15]

Over the next 10 years, these themes can unlock incremental economic value of over USD 200 billion for the health sector and create an incremental benefit of USD 200-250 billion to India's GDP.
(Source: FICCI-BCG Report)

Supportive policies have to match the digital infrastructure to help realise the

complete value. The Ministry of Health and Family Welfare, in March 2020, announced the telemedicine guidelines. The Insurance Regulatory and Development Authority of India followed suit and allowed insurance providers to reimburse for care provided via digital channels. These policy interventions have provided a tremendous fillip to digital healthcare in India.

There are several benefits that will accrue from such a digital health stack – the disparate systems will become integrated and processes will get streamlined; more health data is available to both the healthcare provider and the patient and hence medical care is expected to shift from taking care after an episode to a focus on wellness; new jobs will get created – besides the healthcare workers required in the Health and Wellness Centres under Ayushman Bharat program, personnel will be required for digitization of family records.

Let us consider the impact of the digital health stack on insurance claims processing and see why it can be so transformative. The aim is to create a Health Claims Platform as a public platform, where health providers (like hospitals, primary care centres, or diagnostic labs) submit their e-Claims, and insurers and TPAs (third party administrators) receive these claims via standard APIs. Due to such standardisation and usage of electronic means to receive and process claims, the administrative costs will come down. This in turn may spur the introduction of new insurance products that cover OPD (outpatients) too. In the Indian context, where we typically have 100 outpatients and 6-7 in-patients, insurance coverage for OPD will address the affordability challenge of our healthcare system.

Policy makers believe digitisation in public healthcare will be as successful as it has been in spurring digital payments in a short time-frame of around five years. An NCPI study shows that, by 2021, one third of Indian households have used digital payments and which includes one out of four households in the poorest 40% of India.[16] Digital payments took off thanks to the demonetisation and Direct Benefits Transfer initiatives and the

Telemedicine can be the compelling use-case for digital health adoption in India, like Direct Benefits Transfer was to digital payments.

pandemic-induced shift to cashless transactions. If the national digital health mission is to be successful, it will need a compelling use-case that powers and catalyses the adoption of digital technologies in healthcare. We believe telemedicine can be that catalyst.

Things to consider

While we have so far seen the potential advantages of a digital health stack, we should also consider some of the potential pitfalls.

- Some experts have suggested that 'technologists should be careful to not define (healthcare) 'public good' as what they can conveniently deliver, and instead understand what is actually required…. There must be a careful examination of how exactly digitisation may facilitate better diagnosis and management.'[17]

- Others have argued that there is reluctance on the part of individual doctors in India, as compared to the Western world physicians, to transition to an EHR system. Indian doctors see about 40–60 patients a day, a figure which is 2-3 times more than what doctors see in the U.S., and thus find inputting clinical notes into EHR platforms a major impediment.[18]

- Digital divide in the society poses challenges to the increasing usage of technology in healthcare, as we have seen in the context of vaccination online bookings. Those at the 'right side' of the digital divide are benefitting much more from using the Internet in every domain than people with the 'wrong side' of the digital divide. They also are better in coping with the negative outcomes (like disinformation, privacy loss).[19] We must ensure that the digital divide does not create new forms of health inequities.

Healthcare, unlike money in case of digital payments, cannot be delivered completely digitally. It needs doctors and the healthcare providers, and technology has to aid and empower them. Let us turn our attention to one such promising application of digital health – telemedicine.

4.2. Telemedicine

The World Health Organisation has adopted, in 2007, the following as the definition of telemedicine –

"The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities".[20]

But the practise of telemedicine is much older. We take a historical journey to trace its origins, worldwide and in India. (See adjoining graphic.) [21, 22, 23, 24, 25, 26, 27, 28, 29, 30]

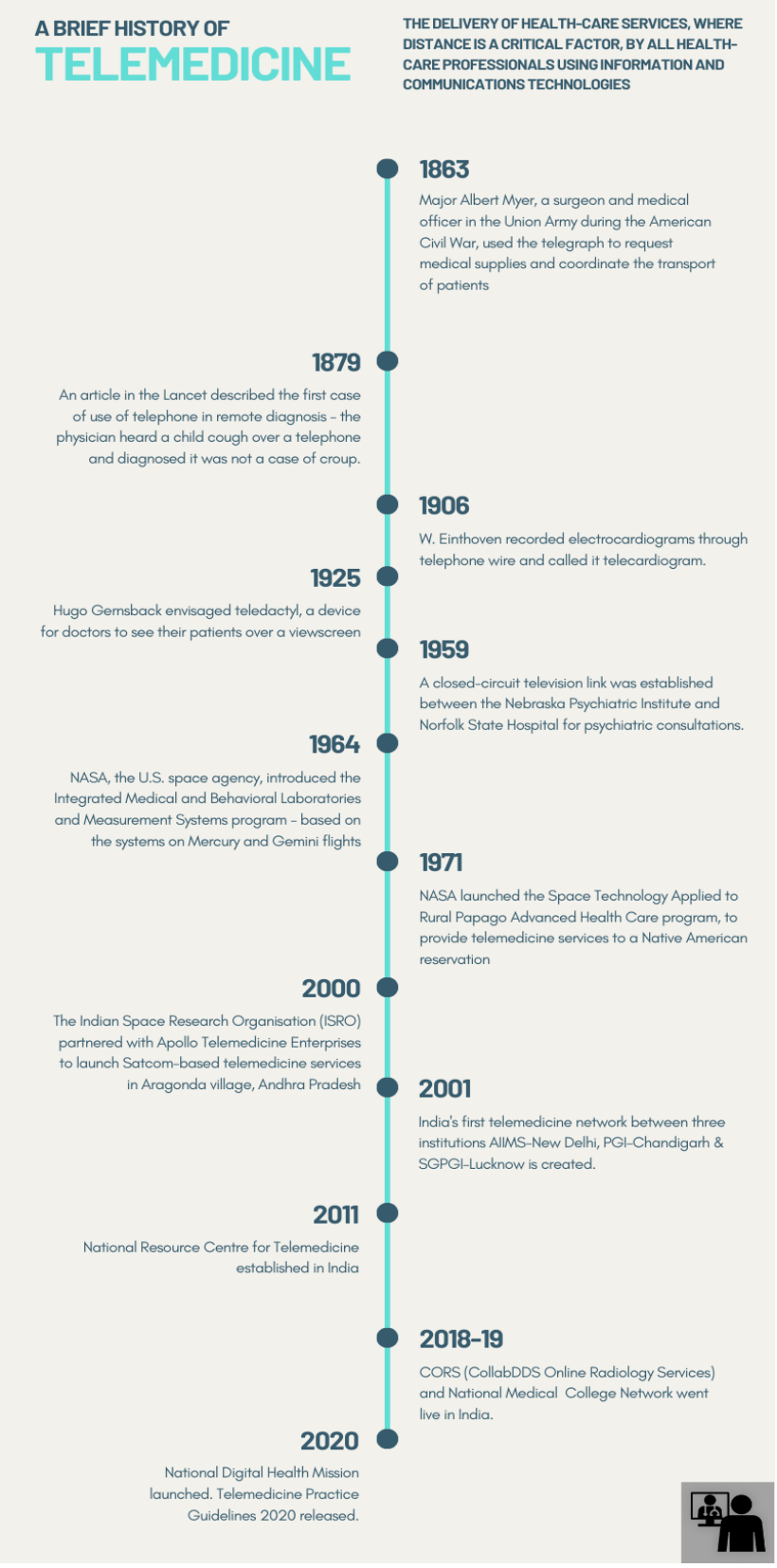


Fig 5: A Brief History of Telemedicine

Telemedicine is over 150 years old worldwide! Yet, it is only in recent times that the adoption of digital technologies in healthcare has picked up speed in India. According to the Future Health Index 2019, 88% of Indian healthcare professionals use some digital health technology or mobile health apps, making India one of the forerunners across the world. Further, 70% of individuals in India say they are likely to track healthcare indicators via digital health technology and mobile health apps, and use that data as a prompt to take action regarding their health and contact their healthcare professional.[31]

The pandemic accelerated the adoption of telehealth. In India, 50 million Indians accessed healthcare online from March to May 2020, with 80 percent of all telemedicine users and patients using it for the first time. (Source: McKinsey & Company)

Shobana Kamineni, executive vice-chairperson of Apollo Hospitals, comments on how the pandemic accelerated their Apollo 24/7 initiative. "We integrated 2,500 of our hospital beds and another 2,000 hotel beds, plus home care, to create a complete COVID-19 solution for thousands and thousands of Indians. It's the largest effort outside government in the country so far. Today, we have about 4 million users of Apollo 24/7, and out of the 4 million, we've seen 25 percent of them come back week after week."[32]

MediBuddy, a digital healthcare platform with a network of over 7000 hospitals and catering to over 35,000 people daily, is seeing a similar trend towards telehealth. Manoj Balaji, SVP and Business Head MediBuddy, says, "Due to the pandemic, telemedicine has gone from a good-to-have to a vital component to address an individual's healthcare needs. People are now more open to telehealth and understand its benefits. Since the pandemic, our platform has seen over 64% growth in individuals opting for teleconsultations."[33]

How does telemedicine address some of India's healthcare challenges? It will allow doctors in cities to consult patients in rural areas, thus alleviating the problem of skewed distribution. Telemedicine also solves the lack of availability of doctors to a

certain degree – in villages, community healthcare workers could do an initial assessment using a checklist and then turn to teleconsultation with a qualified doctor. Some estimates suggest that rather than one doctor seeing 1000 patients, with telehealth, the span of that doctor can increase to 1800 patients. Telemedicine can also be more cost effective: in trials and pilots, it cut consultation costs by about 30 percent. If telemedicine replaces 30 to 40 percent of in-person outpatient consultations, coupled with digitization in overall healthcare industry, India can save up to $10 billion in 2025.[34]

Things to consider

Is telemedicine here to stay in India? Let us consider some perspectives to ensure that telemedicine thrives in the future.

- While the extent to which telemedicine remains post-pandemic, it is safe to imagine that a hybrid model will emerge. As Shobana Kamineni says, "The healthcare model can never be just virtual. It has to be anchored in the omni, the duality of physical and virtual that is this new age of health."

- Doctors and patients, alike, will have to be trained on the usage of telemedicine and digital health platforms – The effectiveness of telemedicine depends on the practitioners' competence in specific skills, some of which are different from those required for a traditional face-to-face medical system. Doctors now need good 'web-side' manners![35]

- Telemedicine best practises, like the Digital Health India Association's scalability-linked framework, which take into consideration the variability in telecom infrastructure as well as end-user expectations across rural, semi-urban and urban settings in India, should guide future implementations.[36]

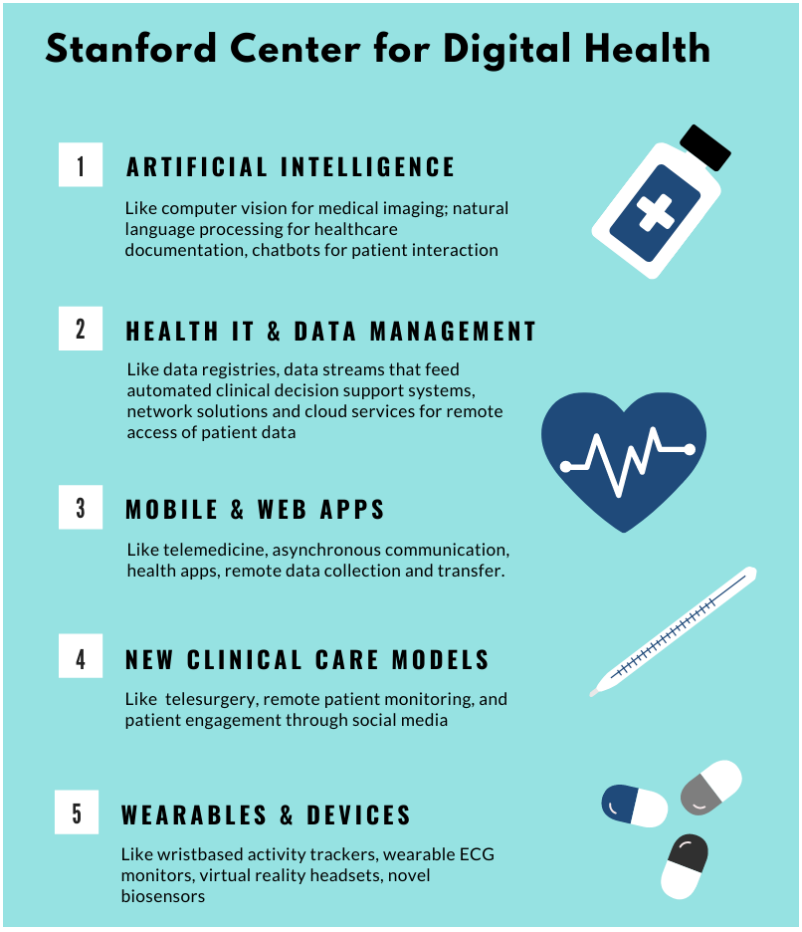
4.3. Startups and healthcare innovations

This is the era of the fourth industrial revolution which is powered by the current technological advances. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological domains. Startups are emerging at the intersection of various digital technologies.

India is home to around 5,295 health-tech startups, out of which 133 are funded eHealth startups. [37] They offer services in areas like online pharmacy, telemedicine, personal health management, home healthcare, fitness & wellness, diagnostics, biotech R&D, medical devices, healthcare IT, biopharma and genomics.

The Stanford Center for Digital Health identifies five digital health technology categories:[38]

1. Artificial intelligence (AI), machine learning (ML), and algorithms (including deep learning, image processing, and advanced analytics)
2. Health IT, infrastructure, and data management (including Electronic Health Record systems)
3. Mobile and web applications (including online SaaS platforms, cloud-based software tools, and social media)
4. New clinical care models (including telemedicine, patient engagement, and patient– physician interaction)
5. Wearables, sensors, and other devices



Let us look at a few examples of startups across these categories, to get a flavour of innovations in action in India.

Artificial Intelligence – BuddhiMed Technologies

BuddhiMed develops Machine learning solutions and analytics tools using very large sets of Indian healthcare data to improve decision making in clinical medicine and healthcare delivery systems. Dr. Ajay Bakshi, its Cofounder and CEO, says, "We have developed a technology that converts unstructured and non-digital data to structured, digital data. For instance, the discharge summaries, insurance claims or even the OPD instructions. Our Knowledge Explorer can extract the diagnosis, procedures and medications in pdf documents from over 10,000 hospitals in India and codify them. Similarly, our Bill Digitizer and Lab Digitizer can extract and codify information from a medical bill and diagnostic lab report respectively."[39]

Once codified, this structured data can be used to build analytics and ultimately create a predictive model of healthcare. Ajay Bakshi explains, "Hospital IT systems in India are extremely fragmented. Even within a hospital, you may find multiple versions of the system which don't talk to each other. If I ask a simple question like, 'Which orthopaedic surgeon is the most cost-effective in doing knee replacements in my hospital?', it will typically take a long time to answer it. One centre will write it as arthroplasty, another will write it as 'TKR', and yet another centre will write it as 'total knee replacement'. Once codified, finding answers to such questions becomes easier."

Health IT – ZBliss Technologies

ZBliss provides an ecosystem of products for intensive care units – a bed-side connectivity hub that runs a specialized custom software to connect to several medical devices, mobile apps for inputting non-device data and analytics, and a SaaS-based solution on the cloud for auto computation of clinical values, data visualization and predictive analytics.

Prashanth Rajagopalan, Director of MGM Healthcare, explains about how his hospital is leveraging IoT and other digital technologies to create a Connected-ICU. "We have leveraged solutions from ZBliss, and various life-saving equipment like the ventilator,

syringe pump, infusion pump, and the monitors are all connected together. Typically, in an ICU setting, a nurse spends a lot of time collecting data regarding 15-20 parameters from the different medical devices, once every hour or two. With a Connected-ICU, all this data is collated automatically, without any errors (that may occur while manually recording). We can also do this in real-time, and do some prediction, for instance in terms of which patients may require intubation."

New clinical care models – Cancer Clinics

Cancer is emerging as a big public health issue in India. The reported cancer cases in India (at 89 per 100,000 population) is less than half the world's reported cases and a third of the cases reported in high Human Development Index countries. However, the current healthcare system in India is woefully underequipped to manage cancer – the challenges of inadequate resources and higher costs, especially in rural India. New models of cancer care are emerging.

Sasi Sunkara, Cofounder and Executive Director of Cancer Clinics, describing the innovations that help reduce access and capacity barriers to cancer-care, says, "We want to be a hyperlocal, tertiary-care provider for cancer. We enable live / synchronous digital access to a highly accomplished oncologist panel. Typically, we enable greater than 60% of visits through teams based in day-care centres set up in existing hospitals. Our digital-first patient journey – including online appointment scheduling, e-Head-to-toe assessment, initial online consultation, and online follow-ups post discharge – enables our oncologists to serve more patients without geographic constraints."[40]

Web Application and Software-as-a-Service – MyLabConnect

The world of dentistry used to be a typically manual process, especially in the way patients were diagnosed and solutions produced. Digital dentistry is becoming a reality, with technologies transforming the entire process – from the way a patient's teeth are diagnosed and scanned, to the design and manufacturing of prosthetics, and to how the dentistry-related data (including patient case files, billing information etc.) is exchanged among different stakeholders in the workflow – dentists, dental labs, DSOs (dental support organizations) and technology providers (design, manufacturing).

Niranjan Ramakrishnan, CEO of MyLabConnect, a startup that offers a SaaS solution for dentistry, says, “A dentist, say in the U.S. may use a digital scanner to digitally scan the patient’s teeth. The intraoral scans are uploaded into our SaaS platform that has a seamless integration from the source scanner, through design bench, and 3D printing and manufacturing. The designers, using CAD/CAM for designing and producing individualised prosthetics, may be sitting in India. We have developed an algorithm which quickly determines if the scanned image is good enough for subsequent design and manufacturing processes. By having access to this analysis in real time, the dentist can rescan when the patient is still on the chair instead of requiring a re-appointment and thus saves time and effort for his/her practice, and also earns higher customer satisfaction.”[41]

Devices: Diagnostic tests using CRISPR technology – CrisprBits

Clustered Regularly Interspaced Short Palindromic Repeats, or CRISPR, is a revolutionary new technology for gene-editing. Also referred to as the “genetic scissor”, the technology is used to cleave DNA / RNA. While CRISPR is known for its potential therapies for various diseases, its application to medical diagnostics has become popular recently. One typically needs a lab and high-end equipment to amplify a nucleic-acid signal in regular diagnostics. Whereas with CRISPR, analysis can be done at room temperatures and at home. Some are even comparing this ‘point of care’ CRISPR-diagnostics moment to the PC-revolution in the IT journey.

CrisprBits is one of the first Indian companies using CRISPR to develop high-quality and affordable healthcare solutions, especially focused on diagnostics. Vaijayanti Gupta, Lead Scientist CrisprBits, says, “We started off developing a robust CRISPR technology platform. The goal has been to tackle diagnostics in TB and other infectious diseases. With the COVID-19 outbreak, we immediately brought in technology that can detect COVID-19. The kit has a Cas enzyme, guide nucleic acids that are complementary to the target sequence (of Covid-19), and a detection platform (like fluorescence or colorimetric analysis).This test is highly sensitive (attomolar level), accurate and produces fast results (typically in hours). We aim to detect COVID-19 not only in nasal

swabs but also in a variety of other sample types, including rapid detection from surfaces."[42]

Things to consider

- While the opportunity space for a startup in digital healthcare is high, it also poses some challenges – a difficult and slower-to-adopt-technology market segment, an industry that imposes important quality, compliance and regulatory demands, and the typically larger time-frames for monetisation / returns on investment.

- There is a need for healthcare specific innovation and incubation set-ups in India. For example, the Healthcare Technology Innovation Centre (HTIC) at IIT Madras and its MedTech Incubator, the Centre for Cellular and Molecular Platforms, or C-CAMP for biotech innovations. NASSCOM CoE for IoT & AI successfully organized Healthcare Innovation Challenge possible solutions to digital technology challenges shared by participating 8 hospitals in 6 areas like out-patients' convenience, cost reduction, inpatient care improvement, pathology digitalization and use of AI.

- Government of India allows 100% FDI in the manufacture of medical devices and offers a 5% PLI scheme for manufacturing medical devices in India. G.S.K. Velu, Chairman and Managing Director at Trivitron Group, says, "What will help medical devices manufacturers in India are two simple things – 1) Government to act as the first consumer and provide sourcing preferences to Indian companies, if quality standards are met 2) Pay on time. Why can't a situation, which is a reality during times of Covid, become permanent?" [43] He also argues for a separate regulatory authority (than DCGI) for medical devices.

4.4. Digital medical education, new healthcare models and regulations

Digital medical education

One of the biggest challenges that healthcare in India faces is the question of skilling and capability building of its doctors and healthcare workers. How can it achieve this in the light of increasing digital health and technology innovations? We will focus only on the aspect of digital medical education here.

The medical world worldwide has been a slow adopter of digital education, with greater emphasis being laid on practical, hands-on, and class-room based learning. Developing countries like India have lack of infrastructure, in terms of sufficient classrooms, medical educators, and other academic resources. Online learning can bridge the gap and strengthen quantity and quality of medical education as it is flexible and adaptable.[44]

A 2020 survey on e-learning in medical education among 3,004 healthcare professionals in India finds that:

- ***65% utilized e-learning platforms during the Covid-19 lockdown***
- ***Although 71% report cyber-security concerns, and only a third consider e-learning to be as effective as traditional learning.***

(Source: https://www.frontiersin.org/article/10.3389/feduc.2021.598309)

Prashanth Rajagopalan, Director of MGM Healthcare, describes the usage of sophisticated technologies for virtual learning in a recent medical case. “We recently had to implant a Left Ventricular Assist Device (LVAD), an ‘artificial heart’, in a four-year old child. The implant was meant for an adult and our doctors had to learn how it would work for a child. So, they built a 3D virtual model using a series of MRI images of the child’s heart. Also, a 3D model of the implant. Then they practised it virtually before successfully conducting the actual surgery.” [45]

Digital medical education can become a reality in India only if it introduced as part of the curriculum. The government set up the National Medical Commission (NMC) in September 2020 with an aim to overhaul the medical education regulation system of the country. NMC's competency-based curriculum has advocated e-learning as a tool for self-directed learning. It also released a module on online learning and assessment to be a part of the new MBBS curriculum.[46]

Another area that could have an impact on digital medical education is around medical license renewal. The Tamil Nadu Medical Council has recommended that licenses be renewed online, once in five years. Is there an opportunity to connect digital education and online medical certifications (for instance, medical MOOCs, continuous learning videos, online lectures / symposiums) to these online renewals?

Other non-medical educational institutions are creating new programs around digital healthcare. For instance, IIT Bombay has announced the launch of a new program around healthcare informatics, offered as an inter-disciplinary dual degree as well as a minor specialisation. The course will include subjects like clinical data management, healthcare standards and ethics, modelling and data efficient machine learning.

New healthcare models & regulations

Other interesting digital healthcare initiatives have emerged during the pandemic, worldwide and in India. Ananth Chandramouli Managing Director - India Market, Capgemini, highlighting the formation of a first-of-its-kind digital health collaboration in Europe, says, "Sanofi, Capgemini, Generali and Orange recently announced the creation of a digital ecosystem dedicated to e-health. The founding companies will share their technologies, expertise and data with selected startups. The project will include a creative lab, a fab lab, a data lab and a living lab, in Paris, to develop, test, adjust and assess solutions for the benefit of patients."[47] Can India create a similar alliance?

Swasth Digital Health Foundation is a not-for-profit consortium of 150+ players in the healthcare ecosystem – hospitals, health-tech firms, pharmacies, and investment funds

– and aims to help India provide quality healthcare using digital technologies. The initial focus of the coalition is to build an effective tele-medicine platform for a large segment of population that doesn't have access to affordable healthcare. It is also working on funding and distributing oxygen concentrators to healthcare institutions. Other organizations include iSPIRT (open house discussions and pilots on national health stack), 10BedICU (setting a ten bed ICU up in a rural hospital), and CoronaSafe Network (open-source software for pandemic management war-rooms).

A number of initiatives have been undertaken in India that focus on creating, monitoring and analysing healthcare data.

- A total of 17 National COVID19 bio-repositories identified by ICMR and other Government agencies will be established: 1) For collecting, storing and maintaining clinical samples of COVID19 patients 2) To judiciously use these samples to promote research and development towards indigenous diagnostics, therapeutics and vaccines in line with the "make in India" initiative
- The Indian SARS-CoV-2 Genomics Consortium (INSACOG) has been set up for genomic surveillance of SARS-CoV-2 in India. Ten laboratories have been designated in India for Whole Genome Sequencing: 1) to ascertain the current status of new variant of SARS COV-2 in the country 2) to establish a sentinel surveillance for early detection of genomic variants with public health implication 3) to determine the genomic variants in the unusual events/trends.
- Ashoka University has partnered with ThoughtWorks to develop the first ultralarge-scale agent-based simulation model for the spread of COVID-19 in India, and once completed plans to make the model available to researchers and policy makers.

India is proposing some important legislations – the Digital Information Security in Healthcare Act ("DISHA") and the Personal Data Protection Bill, 2019 – that will significantly impact digital health. They will also bring to bear new concepts like informed consent and health data privacy. The proposed framework for non-personal data recommends creation of High-value Datasets, which would be helpful for healthcare research purposes.

Kris Gopalakrishnan, co-founder Infosys, commenting on the importance of data, says, "Data should be treated as a strategic asset at a national level. It is important for policy making, improving public service, and supporting a wide range of societal objectives including science, healthcare and so on. Take the case of gene-mapping. Although India has 20% of the world's population, the DNA sequences of its people make up less than 1% of global genetic databases. Such data is required to create healthcare solutions specific for India."[48]

Things to consider

As digital health becomes accepted widely and as new regulations take effect in India, we need to keep in mind some of these considerations:

- Privacy Vs Transparency / Access to health data – the pandemic has brought up a number of instances where we have had to balance the need for an individual's data (based on geo-location, disease incidence etc.) and the need to protect the individual's privacy. Can the greater good of the society always come above individual rights? The healthcare community needs to develop a better appreciation of the evolving regulations. It will start with education.

- Ethical considerations of AI in healthcare – Prof. K. VijayRaghavan, Principal Scientific Adviser says, "What happens to your ability to take decisions on your own, when you get good advice from a machine? This is a very important ethical, moral and social issue. The answer to that lies in making sure that the tools of statistics, computer science, ways of handling data are available to everyone. When I get an AI-based advice, I should have an understanding of how that advice came to me. Also have the ability in my own circle to create tools which can look and give back that community advice in a very different kind of perspective."[49] Healthcare providers have to be trained in using AI-systems in their line of work, and healthcare solution providers have to design products / services keeping responsible / ethical AI considerations in mind.

5. In Summary

The Covid-19 pandemic has catalysed adoption of digital health worldwide and in India, especially in public health response, and healthcare diagnosis and provision.

Digital health in India should help solve the key challenges that Indian healthcare ecosystem suffers from:

i) Lack of resources – India's public expenditure on health has been consistently low and has translated into lower per-capita availability of doctors and other healthcare professionals.

ii) Skewed access and variable quality – In India the density of doctors and nurses in urban areas was 4 times that in rural areas.

iii) Affordability of healthcare – over 62% of healthcare expenditure is predominantly an out-of-pocket-spending.

The future of digital health in India is examined along four perspectives:

1. **National digital health ecosystem**
   a. The National Health Stack will be a shared digital infrastructure, leveraged by both public and private enterprises, to build and provide innovative healthcare solutions. The key building blocks of this digital stack include standardized health registries of doctors and healthcare facilities like hospitals and diagnostic centres, a unique patient Identity (Health ID), and federated health records (PHR and eMR).
   b. There are several benefits that will accrue from such a digital health stack – the disparate systems will become integrated and processes will get streamlined; medical care is expected to shift from taking care after an episode to a focus on wellness; innovative medical insurance products will emerge; and new healthcare jobs will get created.
   c. However, there must be a careful examination of how exactly digitisation may facilitate better diagnosis and management, especially given the context of the Indian physician. We must ensure that the digital divide does not create new forms of health inequities.

2. Telemedicine

a. If the national digital health mission is to be successful, it will need a compelling use-case that powers and catalyses the adoption of digital technologies in healthcare. We believe telemedicine can be that catalyst.
b. We trace the history of telemedicine to over 150 years back. Perhaps the time for its widespread adoption has come during the Covid pandemic.
c. Telemedicine will allow doctors in cities to consult patients in rural areas, thus alleviating the problem of skewed distribution. Telemedicine also solves the lack of availability of doctors to a certain degree – in villages, community healthcare workers could do an initial assessment using a checklist and then turn to teleconsultation with a qualified doctor.
d. Doctors and patients, alike, will have to be trained on the usage of telemedicine and digital health platforms. And telemedicine best practices have to be evolved.

3. Startups and healthcare innovations

a. This is the era of the fourth industrial revolution which is powered by the current technological advances. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological domains. Startups are emerging at the intersection of various digital technologies like IoT, AI, 5G, robotics, and genomics.
b. We considered a few illustrative startups from India covering the gamut of digital health innovations - Artificial Intelligence – BuddhiMed Technologies, Health IT – ZBliss Technologies, New clinical care models – Cancer Clinics, Web Application and Software-as-a-Service – MyLabConnect, Devices: Diagnostic tests using CRISPR technology – CrisprBits.
c. Some ideas to be considered for promoting digital health startups – establish healthcare specific innovation and incubation set-ups in India; set-up a separate regulatory authority for medical devices; and the Government to provide sourcing preferences to Indian digital health startups.

4. Digital medical education, new healthcare models and regulations

a. Digital medical education can become a reality in India only if it introduced and reinforced as part of the curriculum of healthcare professionals.
b. One idea is to consider connecting digital education and online medical certifications (for instance, medical MOOCs, continuous learning videos, online lectures / symposiums) to online medical license renewals.
c. Newer healthcare models driven by the civil society and non-profit private partnerships have emerged. A number of initiatives have been undertaken in India that focus on creating, monitoring and analysing healthcare data.
d. India is proposing some important legislations that will impact healthcare – on digital information security, and patient data privacy.
e. As digital health progresses, we should keep in mind the considerations like privacy Vs transparency / access to health data and ethics of AI in healthcare.

6. References

[1] Jobie Budd et al., “Digital technologies in the public-health response to COVID-19”, Nature Medicine, https://doi.org/10.1038/s41591-020-1011-4

[2] Dean Sitting et al., “COVID-19 and the Need for a National Health Information Technology Infrastructure”, https://jamanetwork.com/journals/jama/fullarticle/2766368

[3] Meera Subash et al., “The emerging role of clinical informatics fellows in service learning during the COVID-19 pandemic”, https://doi.org/10.1093/jamia/ocaa241

[4] William Hersh, MD Professor, "Impact of COVID-19 on Digital Health and Health Informatics", CBIS'20 – XVII Congresso Brasileiro de Informática em Saúde

[5] Niles Peek et al., "Digital health and care in pandemic times: impact of COVID-19", BMJ Health & Care Informatics, http://dx.doi.org/10.1136/bmjhci-2020-100166

[6] https://newsletter.indiaai.in/webview/7dafe058-4c77-4166-94dd-28cbc4943d2c

[7] https://www.aarogyasetu.gov.in/wp-content/uploads/2020/06/mygov-1000000000667755122.pdf

[8] http://www.healthdata.org/india

[9] “Measuring universal health coverage”, The Lancet, 2020, https://doi.org/10.1016/S0140-6736(20)30750-9

[10] https://www.newindianexpress.com/nation/2019/nov/01/indias-public-expenditure-on-health-less-than-lower-income-countries-government-data-2055553.html

[11] Sudhir Anand and Victoria Fan, “The Health Workforce in India”, World Health Organization, https://www.who.int/hrh/resources/16058health_workforce_India.pdf

[12] Jishnu Das et al., “Two Indias: The structure of primary health care markets in rural Indian villages with implications for policy”, Social Science & Medicine, 2020, https://doi.org/10.1016/j.socscimed.2020.112799

[13] http://www.healthdata.org/india

[14] https://ndhm.gov.in/assets/uploads/NDHM_Strategy_Overview.pdf

[15] "Leapfrogging to a Digital Healthcare System", FICCI-BCG, Sep 2020, https://www.bcg.com/en-in/leapfrogging-to-a-digital-healthcare-system

[16] https://www.npci.org.in/PDF/npci/press-releases/2021/NPCI-Press-Release-Digital-Payments-well-entrenched-in-Indian-household.pdf

[17] Subhashis Banerjee , Ambuj Sagar, "What we must consider before digitising India's healthcare", Mar 2021, https://indianexpress.com/article/opinion/columns/national-digital-health-mission-harsh-vardhan-healthcare-sector-7218715/

[18] Aayush Rathi, "Is India's Digital Health System Foolproof?", Economic & Political Weekly, Nov 2019 https://www.epw.in/engage/article/indias-digital-health-paradigm-foolproof

[19] https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2020/08/The-Digital-Divide-and-the-Covid-19-Pandemic-1.pdf

[20] https://www.who.int/goe/publications/goe_telemedicine_2010.pdf

[21] Bashshur RL, Shannon GW, et al., "The empirical foundations of telemedicine interventions for chronic disease management", Telemed J E Health. 2014 Sep, doi:10.1089/tmj.2014.9981

[22] Thomas S. Nesbitt, "The Evolution of Telehealth: Where Have We Been and Where Are We Going?", Nov 2012, https://www.ncbi.nlm.nih.gov/books/NBK207141/

[23] W. Einthoven, The telecardiogram, American Heart Journal, https://doi.org/10.1016/0002-8703(57)90367-8

[24] Matt Novak, "Telemedicine Predicted in 1925", 2012, https://www.smithsonianmag.com/history/telemedicine-predicted-in-1925-124140942/

[25] "A Brief History of NASA's Contributions to Telemedicine", NASA, https://www.nasa.gov/content/a-brief-history-of-nasa-s-contributions-to-telemedicine

[26] P B Angood et al., 'Telemedicine at the top of the world: the 1998 and 1999 Everest extreme expeditions', Telemed J E Health, 2000, https://pubmed.ncbi.nlm.nih.gov/11110635/

[27] https://www.isro.gov.in/update/16-nov-2000/pilot-project-telemedicine

[28] https://www.nhm.gov.in/images/pdf/Telemedicine/Telemedicine.pdf

[29] https://main.mohfw.gov.in/sites/default/files/20%20ChapterAN2018-19.pdf

[30] https://www.nhm.gov.in/

[31] Future Health Index 2019, https://www.philips.com/a-w/about/news/future-health-index/reports/2019/transforming-healthcare-experiences.html

[32] 'https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/building-a-healthcare-ecosystem-in-india-a-conversation-with-shobana-kamineni

[33] Manoj Balaji, MediBuddy, in conversation with Krishnan Narayanan itihaasa Research and Digital

[34] https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/digital-india-technology-to-transform-a-connected-nation

[35] Sambit Dash et al., 'Telemedicine during COVID-19 in India—a new policy and its challenges', Journal of Public Health Policy, Apr 2021, https://europepmc.org/backend/ptpmcrender.fcgi?accid=PMC8131484&blobtype=pdf

[36] https://news.itu.int/in-india-the-opportunities-and-challenges-of-telemedicine-during-covid-19-and-longer-term/

[37] https://inc42.com/datalab/decoding-india-ehealth-opportunity-post-covid-19/

[38] Stanford Center for Digital Health Landscape Report, Nov 2020, https://www.stanforddigitalhealthreport.com/

[39] Dr. Ajay Bakshi, BuddhiMed, in conversation with Krishnan Narayanan itihaasa Research and Digital

[40] Sasi Sunkara, Cancer Clinics, in conversation with Krishnan Narayanan itihaasa Research and Digital

[41] Niranjan Ramakrishnan, MyLabConnect, in conversation with Krishnan Narayanan itihaasa Research and Digital

[42] Vaijayanti Gupta, GKnowMe Consulting, in conversation with Krishnan Narayanan itihaasa Research and Digital

[43] G.S.K. Velu, Trivitron, in conversation with Krishnan Narayanan itihaasa Research and Digital

[44] Saiyad S, Virk A, Mahajan R, Singh T. Online Teaching in Medical Training: Establishing Good Online Teaching Practices from Cumulative Experience. Int J Appl Basic Med Res. 2020;10(3):149-155. doi:10.4103/ijabmr.IJABMR_358_20

[45] Prashanth Rajagopalan, MGM Healthcare, in conversation with Krishnan Narayanan itihaasa Research and Digital

[46] https://www.nmc.org.in/wp-content/uploads/2020/11/Module-8-Online-learning-and-assessment-17-11-20-version-final-for-uploading-converted.pdf

[47] Ananth Chandramouli Managing Director - India Market, Capgemini, in conversation with Krishnan Narayanan itihaasa Research and Digital

[48] Krishnan Narayanan and Sapna Poti, 'STI in the era of new normal – Survey report', Jan 2021, https://www.indiascienceandtechnology.gov.in/stihighlights/sti-era-new-normal-%e2%80%93-survey-report

[49] Ibid