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First published in January 2023
By Centre for Civil Society

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Please cite the work as follows:
Mehta, Bhavya and Paavi Kulshreshth. 2023. Healthcare at Your Fingertips:
Case of mHealth in India. Centre for Civil Society

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Healthcare at Your Fingertips

Case of mHealth in India

Bhavya Mehta and Paavi Kulshreshth

2023

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Preface

It is a widely accepted reality that telehealth can play an instrumental role in reforming India's healthcare infrastructure, filling gaps in physical infrastructure through digitization. Within the broad definition of what all comprises telehealth, mHealth or mobile health is simply defined by the medium of use. mHealth are the health services delivered through mobile devices.

Around the world, Covid-19 led to greater acceptance of and reliance on digitised healthcare services. However, in many nations of the developed world, digital health has been well-established for well over a decade. The telemedicine market in Europe swelled from €4.7 billion in 2007 to €11.2 billion in 2012 (Pozzi 2016). In the developing world with low physician to population ratios, skewness in distribution of healthcare personnel (public-private and rural-urban skewness), unavailability of specialist physicians, among other things, digitisation of health can help bridge gaps in physical healthcare infrastructure and provide for greater choice to the consumers.

Why Digitise Healthcare?

Digitisation of healthcare can fill crucial gaps in a country's physical health infrastructure. This could include digitisation of medical consultations, pharmacies, health data storage and public health messaging. Digitisation can also be applied to more advanced healthcare services. For instance, teleradiology relies on telecommunication networks for the transmission of patients' radiological images for further treatment. Such digitisation can (i) reduce the cost of healthcare delivery, (ii) increase price transparency for consumers, (iii) allow physicians and medical personnel to reach rural and remote populations.

Reduced Cost for Providers

While we are far from digitally-enabled home care infrastructures that can substitute hospital care, digitisation of healthcare services have the potential to increase investment in promotive, preventive, and primary care. Such an increase could reduce expenditure on secondary and tertiary care at the individual, household, and national level.

Digitisation of pharmacies can result in reduced cost of maintaining physical pharmacies, especially for larger operations. Online pharmacies may also have greater visibility and can expand their consumer base. Maintenance of electronic health records can reduce data entry or transcription costs (The Office of the National Coordinator for Health Information Technology (ONC) 2018).

Greater Price Transparency for Consumers

For consumers, the reduction in cost is more significant. India has low voluntary health insurance penetration. For economically vulnerable groups, insurance schemes like the Pradhan Mantri Jan Aarogya Yojana (PM-JAY) offer some relief. PM-JAY covers the cost of secondary and tertiary healthcare up to 5 lakh per household. Most states and Central schemes, however, have closed beneficiary lists. As per a 2021 NITI Aayog report, 40 crore Indians remain uncovered by voluntary private health insurance and any state and/or Central schemes (NITI Aayog 2021). This has resulted in immense out of pocket expenditure on healthcare. Central government estimates suggest that as many as 60 million Indians are pushed into poverty owing to heavy out of pocket expenditure (Vikram 2021). mHealth allows for greater transparency in prices. For instance, online consultation mobile applications or mobile optimised websites may allow consumers to view a doctor's specialisation, years of experience and consultation fee. This allows consumers to choose the price that suits them best. Discussed in greater detail in the pre-pandemic ePharmacies section (section 1.2.2), online pharmacies have lower maintenance costs and can therefore offer greater discounts to their consumers.

Filling Gaps in Personnel and Physical Infrastructure

India's health sector has 0.5 beds per 1000 population, which excludes private beds. If we include the private system, the number shows some improvement at 1.4 beds per 1000 population (FDR 2021, 5). This is well below the world average of 2.9 beds per 1000 population (World Bank Open Data Portal 2017). A significant number of beds are under-equipped and therefore remain unsuitable for critical care. India produces the second highest number of medical graduates per year (80,235 graduates), but we have 0.65 physicians per 1000 population (2016-18) and 1.3 nurses per 1000 population (2017-18) (FDR 2021, 5). Further, skewed distribution of healthcare providers results in concentration of medical staff in bigger cities, while rural, semi-urban and small town populations remain deprived. There exist greater incentives for medical professionals to work in the private sector — higher prices for private healthcare translate to higher incomes. Rural areas have 27% of physicians and 36% of nurses . Additionally, nearly 60% and 70% of inpatient and outpatient care, respectively, is provided by private healthcare providers. 65% of all physicians, 89% of all dentists, 67% of health workers and 93% of AYUSH practitioners are privately employed (Karan et al. 2021). This urban-rural and private-public skewness results in neglect of vulnerable, marginalised groups. Digitisation of health can help reduce the impact of skewed distribution of healthcare professionals by allowing them to reach rural locations without having to physically relocate.

Such personnel shortages and physical infrastructure gaps pose a tremendous challenge to any digitisation efforts. Through e-consultations, the average number of patients per doctor is likely to increase. However, shortage of doctors indicates that despite such an increase many remain vulnerable and without care. Digitization is therefore not a substitute for physical health infrastructure. For India, digitisation must be seen as an additional means of delivering healthcare services. Not as a solution to poor physical health infrastructure.

Why mHealth?

Within the developing world, mobile health or mHealth has emerged as suitable for implementation and scaling of digital health interventions. Although statistics on mobile ownership vary across studies and surveys, they suggest that mobile phones can be the drivers of economic growth and support health systems in the developing world. A 2018 estimate suggests 83% of all adults in the developing world own a mobile phone (Klapper 2019). In November 2022 at the World Media Congress, the secretary of the Ministry of Information and Broadcasting stated that "India has over 1.2 billion mobile phone users and 600 million smart phone users" (Anand 2022). Based on the 'GSMA consumer survey 2020', mobile ownership in India stood at 79% for men and 67% for women (GSM Association 2021). Conducted in 2016, a "Household Survey on India's Citizen Environment & Consumer Economy" reported that 88% households in India have a mobile phone (Bhattacharya 2016). In contrast, statistics on computer ownership, as per a National Statistical Office's survey, reported that 23.4% urban and 4.4% rural households own computers (Gupta 2019). All these statistics on mobile and computer ownership suggest that it would be unreasonable for India to rely on improved access to digital health through computer-enabled healthcare services. Improving access through mobile-enabled health services seems to be a more sound approach, making mHealth particularly attractive for the country, much like the rest of the developing world.

At present, India is among the top ranking mHealth nations in the developing world—a PwC study ranked India second among developing countries studied on "maturity for mHealth adoption" (PwC India, n.d.). The study evaluated 10 countries—Brazil, China, Denmark, Germany, India, South Africa, Spain, Turkey, the UK and the US. Results suggested that 60% of Indian consumers believed that mHealth interventions would improve costs, quality of care and convenience in the next three years (Ibid.).

Thus, we hope that this report is a timely effort to add to the limited literature on the understanding of availability and access to mHealth services in India and guide decision making for policy makers and the private sector in the mHealth space.

Acknowledgements

Insights and experiences shared by stakeholders across the mHealth ecosystem have been valuable in shaping this report. We express our deepest gratitude to Himanshu Burad (Project Lead, Ayushman Bharat Digital Mission) and Umesh Jadhav (Project Lead for Uttar Pradesh Technical Support Unit, ABDM) from the International Innovation Corps for sharing their on-ground experiences of implementing ABDM. We are extremely grateful to Ms Akriti Bajaj (Assistant Vice President, Invest India) and Prof Amir Ullah Khan for sharing their expertise on the healthcare market and health policy scenario of India.

We are extremely thankful to Ms Achitha Jacob (Founder, Proactive for Her) and the TATA 1mg team—Dr Rajeev Sharma (Vice President, Medical Affairs - Content, Public Policy and Regulatory Affairs), Abhishek Agarwal (Program Manager - Offline Growth and Marketing), Saurabh Goel (Head - Category & Revenue Management), Prateek Verma (Vice President, Head of ePharmacy business and Product)—for sharing their first-hand knowledge and experiences of operating in the mHealth sector as service providers.

We extend our gratitude to Manipal Foundation for their generous and continuous support for this study. We are thankful to Ravi, our in-house designer, whose skills have enhanced the visual appeal of this report. Lastly, we also thank our interns (Abhiram Lokanathan, Falguni Mahajan, Aniket Basu and Sara Bardhan) for their contribution in data collection and literature review for this study.

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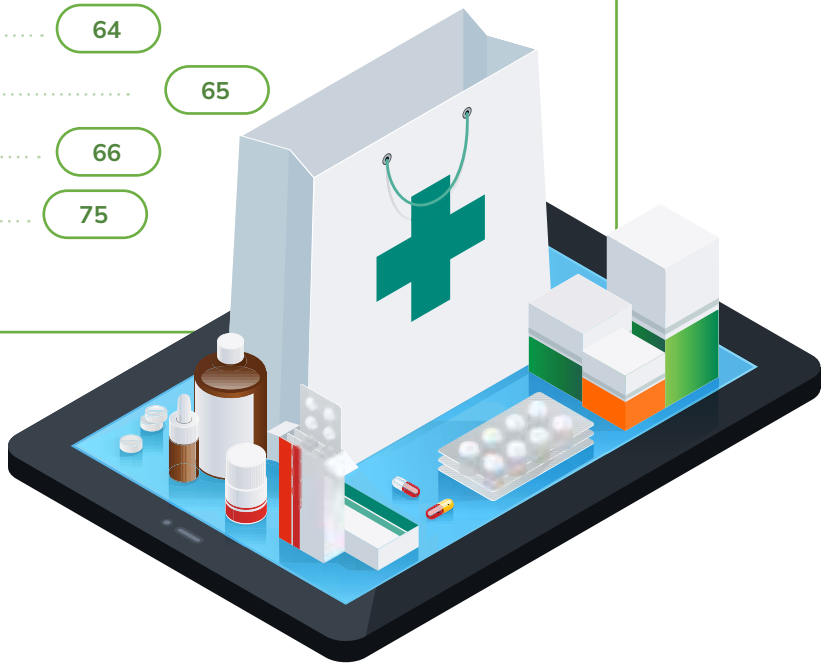


Key Definitions and Concepts

Healthcare	Focused on diagnosing and treating individual patients. It is concerned with provision of medical services that can be provided by both private (for profit and not for profit) and public healthcare providers (includes preventive, promotional, primary, secondary and tertiary, healthcare services)
Public Health	Concerned with preventing diseases and promoting good health for an entire population (such as information related to healthcare services, disseminated for improving access and outcomes)
Health	The term "health" includes both public health and healthcare services. For instance, "improved access to health," implies improved access to both public health and healthcare services.
mHealth	Digital healthcare services like eConsultation, ePharmacy, health data storage, health education services, among others that can be accessed through mobile devices.
Promotive care	Concerned with promotion of good health (eg: consuming nutrition supplements).
Preventive care	Concerned with prevention of diseases (eg: Covid-19 vaccination).
Primary care	Usually the first physician-led (some countries also have nurse practitioners who administer primary care services) point of contact for most illnesses. In most cases, it is the primary care physician who refers patients to specialists for further treatment (secondary or tertiary care).
Secondary care	specialised healthcare provided by specialists like psychiatrists, gynaecologists, cardiologists, etc.
Tertiary care	Highly specialised care provided by specialists over a relatively longer period time at state-of-the-art facilities (eg: dialysis, bypass surgery, neurosurgery, etc).
National Health Authority	is the acronym for the National Health Authority, the apex body responsible for implementing key health missions of India such as "Ayushman Bharat Digital Mission" and "Ayushman Bharat Pradhan Mantri Jan Arogya Yojana"
Ayushman Bharat Digital Mission (ABDM)	Formerly known as the National Digital Health Mission (NDHM), ABDM "aims to develop the backbone necessary to support the integrated digital health infrastructure of the country. It will bridge the existing gap amongst different stakeholders of Healthcare ecosystem through digital highways" (Ayushman Bharat Digital Mission, n.d.).

Digital Public Goods	Similar to the concept of public goods (in economics), digital public goods (DPGs) are also non-rivalrous and non-excludable in nature. The United Nations defines DPGs as "open source software, open data, open AI models, open standards and open content" (United Nations 2020). Some of the Indian digital public goods include Aadhar, UPI, e-sign, Digital Locker, etc.
Unified Health Interface	As per the ABDM website, "Unified Health Interface (UHI) is a network of open protocols that enable the interoperability in health services. UHI is one of the foundational layers in the Ayushman Bharat Digital Mission (ABDM) Stack that focuses on the discoverability and delivery of health services.... Through UHI enabled applications, patients can discover, book, conduct and pay for services offered by a variety of participating providers from any application of their choice" ("What is UHI", n.d.)
Telecom Circles	Indian regions have been categorised into 22 telecom circles, with each circle falling under the category of 'Metro', 'Circle A', 'Circle B', or 'Circle C'. These 22 circles are as follows: • Metro circles: Delhi, Mumbai and Kolkata • Category-A circles: – Andhra Pradesh, Gujarat, Karnataka, Maharashtra and Tamilnadu (including Chennai) • Category-B circles – Haryana, Kerala, Madhya Pradesh, Punjab, Rajasthan, Uttar Pradesh East, Uttar Pradesh West, West Bengal • Category-C circles – Assam, Bihar, Himachal Pradesh, Jammu & Kashmir, North East and Orissa
Latency	Simply put, describes the communication network's time delay (lag). Lower the latency, better the internet experience. Technically, TRAI defines latency as "the time taken by a packet to reach the receiving endpoint after being transmitted from the sending point" (Telecom Regulatory Authority of India 2014).
Kbps	Kilobits per second (used for measuring rate of network transmission or data transfer or speed)
Mbps	Megabits per second. One megabit is equal to 1,024 kilobits (used for measuring rate of network transmission or data transfer or speed)

Executive Summary

A mobile phone's capacity to encapsulate the many wonders of technology has amazed humans time and again. Among the many things you can use your mobile phone for, accessing healthcare is one. At present, India does not fare well in terms of access to primary healthcare and has a skewed doctor to patient ratio (skewed in favour of urban over rural and in favour of paid private healthcare over subsidised/free public healthcare). This is exacerbated by heavy out-of-pocket expenditure on health an average Indian has to make every year. Mobile health or mHealth has emerged as a solution to reduce cost of healthcare, improve access and provide a bouquet of choices to consumers of healthcare. This report explores the evolution of mHealth services, analyses the relationship between technology and access to mHealth and discusses factors that affect the usability and acceptability of mHealth among users.

The market of mHealth in India has evolved from telephone helplines to sophisticated multi-purpose applications that allow users to access online consultations, search and purchase medicine alternatives and even track their own health and well-being. The under-examined evolution and availability of public and private mHealth services in India over the years has been studied in detail in this report. We divided the timeline into early adoption, pre-pandemic adoption, pandemic adoption and the future of healthtech. The report evaluates a range of mHealth helplines, online consultation offerings, ePharmacies, health information apps, etc.

To understand access to mHealth, one must look beyond the internet and mobile penetration rates. The meaningful connectivity framework introduced by A4AI can be a helpful tool in this regard (Alliance for Affordable Internet 2020). Apart from using this tool, understanding the experience of users in utilising technology for accessing mHealth services and a study of benchmarks provides us further insights for a more holistic picture. Thus, in this report, we analyse how technology (and telecommunication, in particular) is affecting access to key mHealth service offerings such as audio and video consultations and how the future of mHealth is likely to look, given the introduction of 5G and the unified health interface (UHI). The concept of meaningful connectivity has been discussed in detail with respect to the original framework (daily use, unlimited broadband connection, appropriate device, 4G-like speed) as well as through the components of digital connectivity, device cost, data price and, digital-first thought.

Lastly, chapter 3 of this report elaborates on ten key factors that affect usability and acceptability of mHealth services in India.

India currently stands at a critical policy juncture, where the National Health Authority is actively working towards developing a network-based, interoperable healthcare ecosystem. We hope this report provides valuable and timely insights to India's rapidly evolving digital healthcare ecosystem.

Key Findings and Insights

India has a **national average of 13.1 Mbps** download speed and 4.4 Mbps upload speed —sufficient to connect to a healthcare provider for an audio or video consultation but drastically below the 2022 broadband goals of 50Mbps for every citizen. Moreover, Indian telecommunication services remain **grossly deficient** in providing good-quality user experience to consumers for both in-app audio and video calls

India requires **co-existence and interdependence** of sophisticated **physical and digital healthcare services**. mHealth service providers are becoming increasingly conscious of this and experimenting with combinations of physical and digital (and online-offline) healthcare services

The likely benefits of the Ayushman Bharat Digital Mission Stack for consumers include the ease of discovering facilities & doctors, **enhanced choice of providers** and more control over the data, **competing prices** and having access to a longitudinal health record containing records from multiple providers and platforms

The **health information and education** mHealth services in India are **largely offered by public sector providers** like the National Health Portal and health departments of state governments. However, a handful of private providers also offer these services

The upcoming Unified Health Interface (UHI) shall provide consumers with **'verified providers'** and **'transparency in pricing'.** The UHI system is based on an open application programming interface (open API) that shall facilitate this interoperability of digital health solutions

Significant **expansion of mHealth services was noted in the pandemic** period as both existing public and private mHealth providers expanded their portfolios and new providers emerged in the market. Certain mHealth providers also reported **considerable increase in users in the pandemic** period

Factors such as technology anxiety, **resistance to change**, social influence, **digital health literacy** are among the many factors that affect usability and acceptability of mHealth services in India

Majority of the mHealth apps studied were **heavy in download size**— requiring both storage space and good internet speed. Multi-access Edge Computing technology may be considered a potential solution in this regard for providers to make their services more technologically accessible for users

Methodology

This study is a result of extensive secondary research, supplemented by information received through primary stakeholder consultations with health experts and mHealth service providers. Primary areas of evaluation include availability, accessibility, usability and acceptability of mHealth in India.

Evolution and Availability

Chapter 1: From a Pipe Dream to a Reality covers the evolution and availability of mHealth in India. To understand India's growing mHealth market, we divided the timeline into four sections—early adoption, pre-pandemic adoption, pandemic adoption and future of health-tech. Early adoption maps the inception of telemedicine in India — initial government interventions, ISRO-led initiatives and private participation in enabling digitisation of healthcare service delivery. For pre-pandemic (2010 - 2019) and pandemic (2020 - 2021) adoption, we evaluated 38 mHealth applications and/or mobile-optimised websites. For the future of health-tech, we evaluated ongoing government interventions in the sector. This included analysing initiatives under the Ayushman Bharat Digital Mission (technological aspects of the mission are covered in chapter 2).

Mobile applications/sites evaluated for understanding pre-pandemic and pandemic adoption were divided into the four major categories:

- Health information & education applications/sites
- ePharmacy applications/sites
- eConsultation applications/sites
- Health data tracking & storage applications/sites

We noted overlaps between these categories. For instance, some eConsulation applications offer pharmacy services and some ePharmacies may also have online doctor consultation options. We relied on the market positioning of a particular mHealth platform for categorisation and subsequent evaluation. For instance, the latest version of MedPlus Mart offers ePharmacy, online doctor consultation and diagnostic services, but its market position is that of a pharmacy. Therefore, we have categories MedPlus Mart as an ePharmacy.

Post categorisation, we reviewed the services offered by mHealth platforms in each category separately. For health information and education applications, multilingual content becomes important; for eConsultation platforms, key services would include in-app or external online chat, audio and video call options; for ePharmacies, provision to upload prescriptions, request out of stock medicines were key services; for health data tracking & storage platforms, key services would include the provision to manually upload health data and vital tracking.

mHealth platforms evaluated in this study include applications/sites offered by private and public providers. These include both made-in-India and commonly used in India (eg: Google Fit) applications/sites. While wearables like smartwatches can be classified as mHealth solutions, this study does not evaluate wearables.

Technology for Accessibility

Chapter 2 of this report focuses on the extent to which technology has fueled access to healthcare in the context of mHealth. To analyse technology for access to mHealth, we first make use of the publicly available Telecom Regulatory Authority of India's (TRAI) data on telecom service providers, wireless subscribers and internet subscribers as well as number of people who have access to the internet through the wireless internet subscription by top four service providers across Indian states.

Multiple sources of information exist for download and upload internet speeds experienced across regions in India. A review of the methodology and data collected by TRAI (through MySpeed app), Ookla (a connectivity insights company) and Opensignal (a mobile network insights company), showed that insights by Opensignal not only cover the internet speed (upload and download in Mbps) but also assess a number of other parameters including experience of the user with regard to video, audio and gaming. Ookla reports download speed (in Mbps), upload speed (in Mbps) and latency (in milliseconds) for Airtel, Jio, Vi, while MySpeed reports only download (in Mbps) and upload speed (in Mbps) for BSNL, Airtel, Jio, Vi.

Based on this methodology review and availability of information (across parameters), Opensignal data published in April 2022 (measured from 1st December to 28th February 2022), was used to analyse access based on parameters such as internet speeds (download and upload, in Mbps), internet-enabled in-app voice calling experience and video experience provided by the four top telecom service providers of the country across 22 telecom circles—Airtel, Jio, Vi, BSNL. This data helped us map the current user experience and internet access and compare it with the several suggested standards for mHealth services such as audio consultations, video consultations, etc.

The developments related to 5G, including its bidding and the announcement of the first few 5G plans, took place during the course of this research study. We closely followed these developments and have provided an insight into what 5G is likely to change for mHealth access in India's near future.

We discuss what does it mean to have meaningful connectivity in the present day scenario and where India is placed right now with respect to the 4Ds: digital connectivity, device cost, data price and digital-first thought.

Lastly, we discuss the features of the ambitious and rapidly developing Ayushman Bharat Digital Mission (ABDM) of the National Health Authority (NHA), the nitty gritties of the ABDM Stack and its network of open protocols—the unified health interface (UHI). We majorly rely on the official websites, reports and event recordings/briefings of the NHA events, available in the public domain. Our conversations with stakeholders working on the implementation of the mission also contributed immensely to refining our understanding of the unique architecture of this system.

Usability and Acceptability

Literature review of usability and acceptability studies on mHealth services across the world showed that the 'technology acceptance model' (TAM) and its evolved versions (including TAM2, UTAUT and UTAUT2) are the most widely used frameworks for studying adoption. Some researchers have modified these models to add new variables to the study, as deemed relevant for the context of their respective studies. Other than TAM and its evolved versions, some researchers have created new models to study the effect of factors such as service quality and quality of life.

Chapter 3 of this report uses the results of various academic papers (using and not using TAM) and reports (such as the GSMA Mobile Gender Gap Report) to analyse the effect of a total of 10 key factors on usability and acceptability of mHealth services. These factors are as follows: experience and technology anxiety, resistance to change and trust, social influence, gender, risk averseness and perceived risk, context-based usefulness, digital health literacy, perceived physical condition, geographical location and service quality. It is important to note that the factors discussed in this report do not depict an exhaustive list and rely solely on limited secondary research. The references may be used by the reader for reviewing the in-depth analysis done by researchers focusing on a specific factor(s).

Lastly, information received from some of the stakeholder and expert consultations have been utilised to fill gaps in the available information and to refine our understanding of the on-ground challenges, realities and recent developments in the mHealth market of India.

Chapter 1

From a Pipe Dream to a Reality

In 2020, the Indian mHealth market had over 3 lakh applications (Kumar 2021). A significant share of these, however, are abandoned by developers and/or have severe functional errors. Services offered by these applications include online doctor consultations, lab testing, health information/education, pharmacy services, workflow management for healthcare providers, health data tracking and storage, etc. Based on usage, mHealth applications can be categorised into (i) for healthcare providers and (ii) for healthcare consumers. The scope of this study is limited to mHealth applications for healthcare consumers, or consumer-facing applications. These include mobile applications or mobile optimised websites that provide direct-to-consumer health information and education, doctor consultations, pharmacy services, health data tracking and storage. They may offer a single service or a combination of online healthcare services.

To understand the development of India's mHealth landscape, we divided adoption — demand for and supply of telemedicine — into a timeline (see Figure 1). Early Adoption covers the inception and history of telemedicine in India. Pre-pandemic adoption and pandemic adoption focuses on the development of the consumer-facing mHealth market (includes public and private mHealth providers). Future of Health-tech covers latest developments (till Oct 2022) and the potential of the consumer-facing mHealth market and government interventions.

Figure 1: Timeline used in this report for analysing mHealth services in India

1.1 Early Adoption

One can say that using technology and/or telecom for improving availability of healthcare services in rural/remote locations, and addressing the skewed distribution of services and personnel, is not a novel thought. In 1997, National AIDS Control Organisation (NACO) launched a pilot project that offered a toll free number for enabling "computerized information and coun seling on telephone," for HIV/AIDS management (MoHFW, GOI 2000). This can be seen as a starting point for the establishment of India's National AIDS Helpline, launched in 2014 (toll free no: 1097). In December 2002, Population Services International (PSI) India (non-for-profit) began Saadhan Helpline offering information and support related to HIV/AIDS. In 1999, Apollo Hospitals set up the Apollo Telemedicine Networking Foundation (ATNF) (not-for-profit) (Ganapathy and Ravindra 2009). In 2000, Apollo Hospitals partnered with the Indian Space Research Organisation (ISRO) to connect through VSAT an Apollo specialty hospital in Chennai with a hospital in the village of Aragonda, Andhra Pradesh. For the first time, tele-consultation was provided using satellite technology (video conferencing system and VSAT provided by ISRO). In 2001, ISRO began its Telemedicine Pilot Project. In 2002, Amrita Institute of Medical Services (AIMS) partnered with the Telemedicine Pilot Project to provide teleconsultations for specialist care at the Indira Gandhi Hospital, Kavaratti, Lakshadweep — a successful display of telemedicine's potential for reaching populations in remote locations, thus, improving access (Amrita Vishwa Vidyapeetham 2006).

The primary objective of early telemedicine interventions, largely implemented under PPP models, was to connect ill-equipped hospitals and/or care centres with better-equipped secondary and tertiary (or speciality) care centres. These speciality centres were saturated in developed urban regions of the country. ISRO's Telemedicine Network was similar in this regard. A February 2005 report suggests ISRO's Telemedicine Network connected 78 remote/rural/district hospitals and mobile health centres to 22 speciality hospitals located in bigger cities like Bangalore and Chennai (ISRO 2005).

In November 2004, the Central government launched the Integrated Disease Surveillance Project (IDSP) (Integrated Disease Surveillance Programme, n.d.). Launched with assistance from the World Bank, the IDSP was an IT network connecting over 776 sites, established with the help of National Informatics Centre (NIC) and ISRO. The IDSP was an IT-enabled disease surveillance system. The IDSP still exists and is part of the National Health Mission. In 2005, the Ministry of Health and Family Welfare (MoHFW) established the Indian Taskforce for Telemedicine. 2005 also saw the launch of Freedom HIV/AIDS — mobile games designed to spread awareness about HIV/AIDS among rural and young populations. The games were designed for low-cost devices that only support black and white colours. This was a result of a public-private partnership between ZeroMQ (a computer program by iMatix Infosolutions) and Delhi State AIDS Control Society (an autonomous body of the Delhi government). The latter was a knowledge partner responsible for authentication of HIV/AIDS related messaging. ZeroMQ later partnered with Reliance Infocomm, which had a majority rural subscriber base. A program report on ZeroMQ's website indicates that the games witnessed 42 million downloads in 15 months—it also suggested that the majority demand was coming from "media-dark" regions of the country (areas that lacked access to broadcast and/or print media) (ZMQ Development, n.d.).

A 2007 report suggested that of India's 19 million blind and visually impaired people, 15 million were located in rural India.

Assisted teleconsultations at rural care centres with ophthalmologists, usually located in neighbouring urban centres, played an important role in early detection of eye problems and preventing increasing number of visual impairment and blindness among rural populations.

In 2006, Madras Diabetes Research Foundation (MDRF), supported by World Diabetes Foundation (WDF), Denmark, launched the MDRF-WDF Chunampet Rural Diabetes Prevention Project. Under the project, a telemedicine van was used for screening of "diabetes and its complications using retinal photography, Doppler imaging, biothesiometry, and electrocardiography using standardised techniques" (Mohan et al. 2012). A rural diabetes centre for basic care was also set up. The project was implemented in a 42 village cluster, including Chunampet and neighbouring villages in Tamil Nadu. Between 2007-10, rural India also witnessed an increase in tele-ophthalmology. Assisted teleconsultations at rural care centres with ophthalmologists, usually located in neighbouring urban centres, played an important role in early detection of eye problems and preventing increasing number of visual impairment and blindness among rural populations. A 2007 report suggested that of India's 19 million blind and visually impaired people, 15 million were located in rural India. Early projects included Sankara Nethralaya Teleophthalmology Project (SNTOP), provided by Sankara Nethralaya, a charitable eye hospital in Chennai, through ISRO's satellite connectivity. The project relied on customised telemedicine vans that came with a social worker (responsible for spreading awareness and creating demand for eye check-ups) and optometrist (can provide screening, diagnosis and treatment for eyes) who were connected to ophthalmologists (provide medical and surgical treatment for eye conditions). The optometrist conducts the eye test (or ophthalmological examination) for the patient, both are connected to the ophthalmologist through a video conferencing system. Most of these early rural telemedicine programs focused on screening and early detection of illnesses among rural populations. All such programs were assisted because of the nature of care. mHealth interventions, more prevalent today, cover healthcare services that may not necessarily require the physical presence of a diagnostician. However, assisted care at rural care centres may remain a reality due to lack of digital literacy and acceptability among consumers (covered in the following chapters).

In 2007, Ericsson launched Gramjyoti Rural Broadband Project. Arguably, this was India's first rural broadband demo network powered by high-speed access packet (HSAP), providing 3G connectivity to 18 villages in Tamil Nadu. In September 2008, following the success of Gramjyoti, Ericsson partnered with ATNF to bring to the 18 villages an mHealth project to "promote, publicise and implement the use of telemedicine as an application over broadband-enabled mobile networks'' (The Economic Times 2008). Detailed reports on the programme remain limited, but the initiative can be viewed among India's first consumer-facing (not assisted) mHealth services.

Table 1 lists government-run/supported telemedicine interventions between 1996 and 2010. A 2008 National Health Mission (NHM) presentation suggested that besides the government and Centre for Development of Advanced Computing (of the Ministry of Electronics and Information Technology), India's telemedicine industry players at the time included Apollo Telemedicine Networking Foundation (Apollo Hospitals Group), Televital India Pvt Ltd, Prognosys Medical Pvt Ltd, Medisoft Telemedicine Pvt Ltd, Online Telemedicine Research Institute, India Vepro Medical Informatics Pvt Ltd, Karishma Software Ltd, and I-diagnosis Technologies (Mishra 2008). A popular mHealth provider (private) today, Practo began early. In 2009, Practo Technologies Pvt Ltd (formerly TurboDoc.in) offered healthcare

software-as-a-service (SAAS) platform (HPS) for doctors to manage patient records, schedule appointments and provide e-prescriptions and bills to their patients. Post the success of its B2B model, in 2013, Practo launched its consumer-facing doctor discovery and appointment booking.

Table 1: Evolution of Telemedicine in India: Brief Summary

Year(s)	Brief Summary
1996	Deployment of First Indigenously Developed Hospital Information System Software by CDAC Noida at SGPGIMS, Lucknow, Uttar Pradesh
1999 (pilot)	Indigenous Development of Telemedicine Technology & Pilot Deployments by DeitY, MCIT, Govt. of India at AIIMS, New Delhi, PGIMER Chandigarh & SGPGIMS Lucknow
2000	SATCOM based Telemedicine Deployment by ISRO at Apollo Hospitals, Aragonda
2001	First telemedicine network between three institutions AIIMS-New Delhi, PGI-Chandigarh & SGPGI-Lucknow First National Conference on Telemedicine was held & a Scientific Body for promotion of Telemedicine in the country, Telemedicine Society of India, was formed
2001 - 03	Major Medical Institutions (Govt. & Corporate) initiated Telemedicine activities and deployed hospital information system
2003 - 04	Deployment of SATCOM based TM nodes across the country by ISRO for Tele-education and Tele-consultation services
2005	MoHFW constituted Indian Task Force for Telemedicine
2006	Planning Commission approved budget for e-Health including Telemedicine in the 11th Five Year Plan; School of Telemedicine & Biomedical Informatics (STBI) was set up at SGPGIMS, Lucknow by Govt. of Uttar Pradesh; PHFI was awarded Grant-in-aid to have MoHFW "Healthy India" Website for Health Education from 2007-08 to 2012- 13
2007	STBI at SGPGIMS, Lucknow was made National Resource Centre for Telemedicine & Biomedical Informatics by DeitY, Govt. of India; MoHFW, Govt. of India supported Tele-ophthalmology Project in many parts of the country; MoHFW, Govt. of India supported Onco-NET Project
2009	MoHFW supported National Rural TM Network with Rs. 25-50 Lakh to start the pilot projects on Telemedicine
2010	National Medical College Network Project Conceived. SGPGIMS was made National Resource Centre for Telemedicine by MoHFW MCTS Launched by MoHFW, Govt. of India

Source: Telemedicine Division, MOHFW, Government of India, n.d.

Mid-term appraisal of the 11th Five-year Plan (2007-12) suggested slow uptake of telemedicine in the country. By the 12th Five-year Plan (2012-17), telemedicine (under the budget head Electronics in Health and Telemedicine) was an important focus area. Revised estimate for the 11th Plan for telemedicine was over INR 65 crore, however, the proposed outlay in the 12th plan was INR 50 crore (Government of India Ministry of Communications & Information Technology Department of Information Technology, n.d.). The 12th Plan stated that government-run/supported telemedicine pilot projects were implemented in 6 states, including Punjab, Tamil Nadu, West Bengal and Tripura. These projects were implemented by respective state governments. As per the 12th Plan, "A Mobile Tele-Oncology system was implemented for extending the coverage of ONCONET- Kerala to the rural masses. Using the system, 43 medical camps have been conducted so far covering a population of about 87000 over three districts" (Ibid.). ONCONET Kerala was India's first tele-oncology network that connects talukas to cancer centres/hospitals. It provided "information related to medical

treatment, sharing of resources and an integrated health care delivery system using various media, for example, telephone calls, video conferencing, remote monitoring and consultation using tele-otoscope, tele-stethoscope, tele-radiology and remote microscope" (National Health Mission 2009)(Appendix).

1.2 Pre-pandemic Adoption

In this section, we will cover consumption/demand and provision/supply of consumer-facing mHealth services (offered by private and public providers) and government interventions that enabled growth of consumer-facing mHealth availability in India between 2011 and 2020.

Even in the pre-pandemic years, India was ranked high on market potential. A PWC study analysed mHealth market potential for India and other nations (largely reliant on 2012 data). The study indicated patient or consumer willingness to switch to mHealth services — 43% patients and healthcare providers coordinated over mobile phones, 44% used mobile phones to learn more about wellness (PricewaterhouseCoopers LLP 2014). Such an inclination towards using mobile phones to communicate with doctors is not limited to having access to mHealth applications. Increased use of mobile phones to access healthcare services views healthcare as a consumer good, adopting a patient-as-consumer approach. Physicians, on the other hand, displayed resistance to mHealth adoption — 27% encourage their patients to opt for mHealth, 53% physicians worried about patient independence w.r.t managing their own health (Ibid.).

In 2014, the Ministry of Health and Family Welfare launched the National Health Portal (nhp.gov.in), aimed to serve as a single source for health information for citizens, including sector-specific information for healthcare professionals, academics/ researchers, students, and consumers of healthcare.

This decade witnessed the advent of a growing consumer-facing mHealth market. Practo Technologies Pvt Ltd launched its doctor discovery and appointment scheduling website in 2013. This coincided with an ongoing boom in the number of smartphone sales in the country — in 2013, India had the third largest smartphone user base (117 million users) in the world after the US and China (Singh 2015). This meant, smartphone users with internet connectivity could now access Practo's doctor discovery and appointment scheduling website. Lybrate launched similar services through its website and mobile application in 2013. Its services were similar to that of Practo, the application and website allowed people to book doctor appointments and connect with healthcare professionals.

Apollo Hospitals Group, one of the earliest private telemedicine providers and enablers, launched Apollo 24x7 mobile app in 2013. Early services offered by the app included (i) SOS messages to loved ones with a location sharing option, (ii) call rescue services, (iii) list of emergency phone numbers for ambulance service, Apollo Emergency, etc. (iv) location-enabled nearby medical centres — this included a nearby medical facilities map that allowed for easy navigation through a need-based filter (eg: you could choose to view nearby dentists or nearby pharmacies).

In 2014, MoHFW launched the National Health Portal (NHP) (nhp.gov.in). The portal was created to serve as a single source for health information for citizens. This included sector-specific information for healthcare professionals, academics/researchers, students, and consumers of healthcare. By 2016, a consumer-facing mobile application was made available, NHP Swasthya Bharat app. The app provided information on promotive health ("healthy lifestyle"), diseases (treatment, symptoms, first aid), and public health alerts. The app also offered information on symptoms one should not ignore, eg: blood in stool/ urine, chronic cough, etc. In 2015, NHP developed the National Health Helpline (NHP voice web) for sharing authenticated health information (National Health Portal, MoHFW, GoI 2015). Initially. NHP services were offered in English, Hindi, Tamil, Bengali and Gujarati. An identified beneficiary of NHP voice web was the illiterate consumer, who would require audio-visual (in this case only audio) health information and education. In its 2015 announcement, NHP claimed that NHP voice web does not require internet connectivity. This was an IVR service where the "user dials a number from his phone and the call goes to Interactive Voice Response (IVR) system. User then says the reason for the call, for example "Disease". Speech enabled IVR system will process the request and map it to the corresponding functionality and the supported content is played back" (Ibid.). However, the 24x7 toll free helpline number shared (1800-180-1104) is no longer valid. This could either mean that the service is no longer available or that the service is non-functional. State governments have their own mobile optimised websites and mobile applications. The Govt.

of Andhra Pradesh, for instance, launched a call centre for pregnant women. A pioneer in the space has been the Telangana government. In 2014, Telangana's ministry of health was the first to launch a mobile application, offering citizens information regarding 800 government healthcare facilities (primary care and specialist care centres) (Tech Desk, The Indian Express 2014). This information was available in English and Telugu.

For this study, we evaluated 38 mHealth applications (or mobile optimised websites) launched in pre-pandemic years. These include government and private applications. We have classified these apps into four categories based on services offered — (i) health information and education, (ii) consultation and diagnostic services, (iii) pharmacies, and (iv) health data storage and tracking. This is not a rigid classification owing to expansion in services offered. The following sections will cover the nature of services offered by both public and private providers.

1.2.1 Health Information & Education

One cannot demand something one knows nothing of. This is information failure, common in the healthcare market.

Apps that share information are important for driving demand for healthcare, especially preventive care. One cannot demand something one knows nothing of. This is information failure, common in the healthcare market. Consumption of healthcare works differently from consumption of other goods and services. Let's take education, for instance. If monetary cost is not a concern, one is likely to have or seek information about what level of education they require to achieve their career or academic goals, and demand the same (adults can make their own choices; parents can decide for minors). Healthcare doesn't work quite the same. Girls and women require Human papillomavirus (HPV) vaccines, ideally before becoming sexually active, that prevents cervical cancer. However, girls and women are not likely to have or seek this information. Supply of such information through sexual education, healthcare professionals, public health campaigns, and/or the internet, therefore, becomes the only way to drive subsequent demand for HPV vaccines. mHealth services that offer health information and education have the potential to reduce information failure, increase demand for healthcare, and thus, lead to early detection of diseases.

As per our evaluation, mHealth services in this category are largely offered by public sector providers like the National Health Portal and health departments of state governments. We also analysed private sector mHealth applications and mobile optimised websites that offer health information and education. For instance, Flo (mobile application launched in 2015) can help users develop an understanding of one's own menstrual cycle and attain menstrual health education. Proactive for Her (mobile optimised website launched during the pandemic, in August 2020) focuses on sexual health education. However, based on their identified primary services, Flo is categorised as a health data storage and tracking application and Proactive for Her is categorised as a econsultation and care services option.

We evaluated 10 mHealth applications and/or mobile optimised websites and 2 offline mHealth (SMS/IVR) in this category.

Table 2: **Health information and education services launched in pre-pandemic period**

App	Year of Launch	Provider/Developer	Languages
NACO AIDS App	2017	National Health Portal - MOHFW	Hindi, English, Gujarati, Telugu, Tamil, Kannada, Bengali, Marathi, Punjabi, Odhiya, Malayalam,
HealthKartPlus	2013	Bright Lifecare Pvt Ltd	English
Mera Aspataal	2016	National Health Portal - MOHFW	Hindi, English, Gujarati, Khasi, Telugu, Tamil, Kannada
PMSMA	2016	National Health Portal - MOHFW	English
Journey of First 1000 Days	2018	National Health Portal - MOHFW	English, Hindi

App	Year of Launch	Provider/Developer	Languages
MedWatch	2018	Indian Air Force	English
Poshan HealthPhone	2016	Ministry of Women and Child Development, supported by UNICEF	English, Hindi, Urdu, Garo, Khasi, Telugu, Tamil, Gujarati, Bengali, Assamese, Kannada, Konkani, Malayalam, Manipuri, Mizo, Odia, Punjabi, Marathi
Jeevan Shakti	2019	Dept of Health & Family Welfare, West Bengal	English
Vector Borne Disease Control and Surveillance	July 2020 (pandemic app)	Dept of Health & Family Welfare, West Bengal	English, Hindi, Bengali
eRakt Kosh	2016	National Health Portal - MOHFW	Hindi, English

The mHealth information and education mobile applications we evaluated were an extension of existing national initiatives. The NACO AIDS App for instance extends India's national AIDS control efforts by increasing awareness — National AIDS Control Programme, launched in 1992. The application offers services for (i) consumers who are uninfected or unaware of their HIV status and (ii) consumers who are infected or people living with HIV (PLHIV). For the former, preventive care information and education is available on the application. This includes information about common myths related to HIV/AIDS and an HIV risk-evaluator (for assessing individual risk levels). It also provides information on the rights of PLHIV, and provides information to reduce stigma around and discrimination against PLHIV. For PLHIV, the application provides information on the nearest HIV Centres, blood banks, Suraksha clinics, ART centres, ICTC centres.

HealthPhone, launched by the Ministry of Women and Child Development and supported by UNICEF, is a video referencing library that provides nutrition education through audio-visual content. This content is available in 78 Indian languages and consumable by illiterate populations. These videos can be downloaded for free to phones, tablets, PCs. Covering information on nutrition, mother and child health, prenatal practices, etc. these preloaded videos can be consumed by healthcare workers and/or families and individuals on their mobile phones (or tablets and PCs). By 2016, this information was made available through mobile applications – Poshan HealthPhone – available in 18 languages. This mHealth service is also well-aligned with the goals of the 2018-launched Poshan Abhiyan (national nutrition initiative). It claims to address "issues of status of women, the care of pregnant women and children under two, breastfeeding and the importance of a balanced diet, health and simple changes in nutritional care practices that can notably enhance nutrition levels" (Healthphone, n.d.).

HealthKartPlus was launched by Bright Lifecare Pvt Ltd in 2013. Bright Lifecare Pvt Ltd also owned HealthKart.com – an online vendor of health products. HealthKartPlus mobile application was a generic drug search engine where consumers could "explore how prescription medicine works & understand the required precaution and contraindication" (Bhushan 2013). It also allowed for price comparison – the intent was to provide information on cost-effective generic drugs. One could place orders for these drugs after comparing prices and understand the nature of the generic drug. The application offered services in English-language. The identified HealthKart.com and HealthKartPlus separated in 2015, and HealthKartPlus was rebranded as 1mg (Verma 2015). 1mg operated under 1mg Technologies Pvt Ltd till TATA procured the mHealth brand in 2021 (Tata Digital 2021). Today TATA 1mg is a major mHealth player. However, 1mg is no longer limited to health information and education. In addition to playing an informing and education role, 1mg offers consultation, pharmacy and diagnostic services.

India's literacy challenge also limits the scope of applications and/or websites that only offer written health information and education content. Another perceivable challenge across information and education mHealth applications and websites is limited language options. English as a means of communicating health information and education would not work for consumers who do not understand the language. Even those with beginner level English-language skills can struggle with comprehension of medical information. Further, health

information and education can be counterproductive if misunderstood. Availability of native language options, therefore, becomes crucial to meaningful consumption. Government-run applications have been observed to more likely be multilingual or available in native languages.

Table 3: mHealth offline services (SMS/IVR) in pre-pandemic period

Service	Year of Launch	Provider/Developer
99DOTS	2014 (pilot); 2016 (launch)	Microsoft Research, National Tuberculosis Elimination Programme
mCessation	2016	National Health Portal - MOHFW
102 Call Centre for pregnant women	2015	Dept of Health, Medical and Family Welfare, Govt of Andhra Pradesh

mHealth offline services for information and education in the pre-pandemic era included some unique solutions for effective healthcare delivery. 24x7 helplines covered in this section were launched in the late 2010s. While the use of mobile phones at the time was common, it is important to note that helpline and/or IVR services are available through fixed wireline telephonic communication as well. SMS-based mHealth services are the mobile-only offline services covered in this section.

Helplines, SMS and IVR-based mHealth services

Toll free number '108' was common across multiple Indian states for emergency ambulance services. Between April 2013 and March 2014, over 6 lakh pregnancy related calls were received by Andhra Pradesh, Telangana, Himachal Pradesh, Assam, Gujarat, and Chhattisgarh (Singh et al. 2016). In 2015, Andhra Pradesh government launched the 102 Call Centre for pregnant women – a dedicated means of addressing pregnancy related transport and neonatal care requirements (for both mother and child). 102 Call Centre also bridged an important information gap. A challenge that plagues healthcare markets is lack of transparency w.r.t prices and quality of care. Among stated objectives of 102 Call Centre for pregnant women are "gauging public perception and satisfaction on services" and "monitoring the services provided to the pregnant women with special focus on high risk pregnant women" (Department of Health, Medical & Family Welfare, Andhra Pradesh, n.d.). The services are limited to public healthcare facilities. Such monitoring and evaluation can help improve quality of care by creating a telecommunication-enabled feedback mechanism. Consequently improving transparency vis-a-vis quality of care.

Lack of information and transparency about prices and quality of care plague the Indian healthcare market.

The mCessation programme was among early SMS & IVR-based mHealth services, launched by the Indian Ministry of Health and Family Welfare, in partnership with the World Health Organisation and the International Telecommunications Union. Tobacco is consumed by an overwhelming 29% of all adults in the country as per the Global Adult Tobacco Survey India, 2016-17 (World Health Organization, n.d.). Aimed at tobacco cessation, this offline mHealth service allows individuals who wish to quit tobacco to register on the National Health Portal website or give a missed call on 011-22901701. These registered users are supported through constant text messaging and communication with programme specialists.

Another similar SMS & IVR-based intervention is part of the National TB Elimination Program. TB is endemic in India — estimates suggest India accounted for 34% of the global total of 1.48 million TB deaths. The biggest challenge with diagnosed TB patients is often low medication adherence. Patients diagnosed with TB must continue medication for 6 months. This is often a challenge given that patients begin to feel better within the first month of medication. They may then require constant nudges to continue medication. DOTS (Directly Observed Therapy Short-course) is a way of tackling this challenge – patients are required to visit healthcare facilities and take medication in the presence of a healthcare worker.

99DOTS is a mobile-based alternative to DOTS. As per the 99DOTS website, the service can be used:

"Either as a supplement to existing DOTS programs, or to enable remote observation of doses administered by patients or their family members. Using 99DOTS, each anti-TB blister pack is wrapped in a custom envelope, which includes hidden phone numbers that are visible only when doses are dispensed. After taking daily medication, patients make a free call to the hidden phone number, yielding high confidence that the dose was "in-hand" and has been taken. It is important to note that 99DOTS requires only a small number of phone numbers. The numbers called by a patient may repeat over time; however, on each blister pack, the numbers are arranged in an unpredictable sequence. As treatment progresses, the sequence of numbers called is checked against the blister designs, thereby verifying that the patient is taking medication as intended. 99DOTS patients receive a series of daily reminders (via SMS and automated calls). Missed doses trigger SMS notifications to care providers, who follow up with personal, phone-based counselling. Real-time adherence reports are also available on the web"

(99DOTS Deployments, n.d.).

This mobile-based treatment monitoring system developed by Microsoft Research was first launched in India, under the Revised National Tuberculosis Control Programme, in 2016. 99DOTS is now an important part of India's National Tuberculosis Elimination Programme. While this mobile-based solution allows healthcare professionals to monitor medication adherence among TB patients, SMS and IVR-based daily reminders to patients also make it a consumer-facing solution.

1.2.2 ePharmacies

In India, all expenditure on over-the-counter and prescribed medicines is out of pocket expenditure. As per National Health Accounts 2018-19, total out of pocket expenditure by households was INR 2,87,573 crore. Of which, expenditure on prescribed medicines was INR 1,01,928 crore and expenditure on over-the-counter medicines was INR 18,881 crore (National Health Systems Resource Centre 2022). At the Centre, Jan Aushadhi scheme was launched in 2008. Government of India rebranded the scheme as Pradhan Mantri Bhartiya Janaushadhi Pariyojana (PMBJP) in 2016 – the government claimed this would grant the scheme "further impetus" (as of January 2022, official estimation claims there are over 8600 jan aushadhi kendras/stores across India). Stated objectives of the scheme include (i) making cost of "quality medicines", consumable and surgical items affordable to reduce out of pocket expenditure; (ii) popularing generic medicines and undo the notion that generic medicine are low quality or less effective; (iii) ensure easy availability of menstrual hygiene products (Jan Aushadhi 2022). National Health Mission's (NHM), Free Drug and Diagnostics Initiative provides free essential drugs at public health facilities. The initiative is implemented by state governments. In 2019, Rajasthan ranked 1st in NHM's assessment of state-level implementation (Ali 2019). While such schemes provide some relief to socio-economically vulnerable groups, out of pocket expenditure on drugs remains high and requires market-led change.

In 2018, the reported market share of online pharmacies was 1%; brick and mortar comprised the remaining.

Source: Bansal 2018

Online pharmacies or ePharmacies can bring about this market-led change. In a 2018 interview Prashant Tandon, CEO of 1mg, claimed that ePharmacies can offer lower prices than physical stores. Prices can come down by 10-20% as ePharmacies can save on the cost of setting up a physical store. Tandon argued,"If the drugs cost about Rs 25,000 a year, a 10-20% reduction in drug prices can result in lifelong savings for the patient [with higher drug requirements, like cancer patients]" (Chitra 2018). In 2018, the reported market share of online pharmacies was 1%; brick and mortar comprised the remaining (Bansal 2018). Later, a 2019 paper suggested ePharmacies held 3% of the market share (Satheesh, Puthean, and Chaudhary 2019). Despite the low market share, in 2016, the India's All India Organisation of Chemists and Druggists (AIOCD) opposed GOI's draft proposal to formalise ePharmacies. The opposition was justified stating public health risks with the emergence of online pharmacies. The AIOCD claimed that online pharmacies were selling habit-forming

drugs and not verifying the authenticity of prescriptions. These claims were reportedly denied by established top ePharmacies (The Economic Times 2016). The AIOCD also voiced concern over the impact ePharmacies would have on the livelihoods of physical pharmacies. This is important to note to understand the pre-pandemic sentiment towards ePharmacies. Theoretically, ePharmacies are likely to offer lower prices than physical pharmacies. This is similar to how Amazon and Flipkart offer lower prices or more discounts than physical retailers. Much like regular retailers, physical pharmacies would also have to enter the online marketplace.

For our study, we evaluated 5 pre-pandemic ePharmacies (refer Table 4) mobile applications (all have mobile-optimised websites). We also evaluated the Jan Aushadhi Sugam mobile application. Based on services offered, the application fits better in the health information and education category. For ease of understanding, however, the application has been included in this section.

Jan Aushadhi Sugam application was launched in 2019. It may not be classified as an ePharmacy. It offers (i) information on the nearby jan aushadhi kendras/stores, (ii) a search function for generic medicines, (iii) price comparison between generic and branded drugs, and (iv) a feedback mechanism where consumers can leave comments and make suggestions. Consumers can, however, call and order drugs from nearest jan aushadhi kendras that offer delivery service (our evaluation indicated that these kendras use courier service for delivering the drugs in Delhi). The number of nearest jan aushadhi kendras is available on the mobile application. The app also has a "useful links" feature that leads consumers to mobile optimised websites of NHP, Ministry of Ayush, Dept of Pharmaceuticals, PMBJP, National Pharmaceutical Pricing Authority, and WHO. Consumers can access these useful links, information on nearby kendras, and the medicine search function without having to login. For sharing feedback, however, users must login. The application is multilingual, and offers services in English, Hindi, Gujarati, Assamese, Bodo, Bengali, Malayalam, Odia, Punjabi Tamil, Urdu, Telugu, Kanada, Marathi, Nepali, Maithili, Sanskrit, Sindhi, Santhali, Konkani, Kashmiri, Dogri, and Manipuri. It is available on both iOS and Android.

MedPlus is among the oldest pharmacy chains, started in 2006 in Hyderabad. Since its inception, MedPlus claimed supply chain efficiency and cost effectiveness through technology. The company reportedly used data analytics to understand demand. In 2015, they switched to an omnichannel business model, offering online services to their consumers. MedPlus Mart, the online pharmacy of MedPlus, presents an interesting example in the ePharmacies space. The company had a well established offline presence prior to moving to an omnichannel. This allowed the firm to leverage its existing offline infrastructure to provide online services. In 2017, the COO of MedPlus Mart, Dr Surendranath Mantena clarified that the pharma provider does not differentiate between online and offline services – "We see everything as a holistic kind of business. MedPlusmart.com contributes 10% revenue to our company" (Avvannavar 2016). The COO also claimed that once an online order was placed, medicine availability at the nearest store is ensured. Mantena added, "We also send SMS alert to customers to collect the medicine." As of June 2021, MedPlus had over 2100 physical pharmacies across 242 cities in Tamil Nadu, Andhra Pradesh, Telangana, Karnataka, Odisha, West Bengal and Maharashtra (MedPlus, n.d.). While our evaluation is limited to MedPlus Mart's ePharmacy services, by October 2022, it also offered online diagnostic and doctor consultation services.

The reason why MedPlus is an interesting and important example in the Indian pharmacy industry is because it shifted from an offline retailer to an omnichannel model that offered online services. Our conversation with TATA 1mg suggested that the mHealth provider is creating an omnichannel presence by offering various healthcare products and services to consumers even through brick-and-mortar retail stores. HealthKartPlus was rebranded as 1mg, an ePharmacy that provided prescription and over-the-counter drugs, in 2015 (refer section 1.2.1). A 2019 video released by 1mg indicates the existence of diagnostic and doctor consultation services in the pre-pandemic era. However, the doctor consultations offered by 1mg are different from mHealth platforms that focus on consultations and consumers can browse through multiple doctor profiles (their qualifications, consultation fee, specialisations, etc). As per our evaluation (as of Oct 2022), consumers chat with a "Health Assistant" first, which collects information about the consumer's concern. Consumers can also attach a prescription or lab reports at this stage. Based on the concern and shared details, 1mg auto-assigns a doctor. The doctor consultation can be done over chat, voice call or video call. Non-urgent queries are addressed for free on 1mg. Consumers have to pay a fee for faster responses.

After separating from HealthKartPlus (now Tata 1mg), HealthKart became an online platform for fitness and nutrition products. This platform may not be considered an ePharmacy because it does not provide prescribed or over-the-counter medicines. In our evaluation, however, we have included HealthKart in this category because it offers health and nutrition products that may aid promotive healthcare. These include vitamins and mineral supplements (eg: iron folic acid tablets) and Ayurvedic products (eg: Ashwagandha tablets).

ePharmacies often allow consumers to check for the availability of alternate drugs that treat the same or similar concerns as the drug they are searching for.

NetMeds and PharmEasy are also pre-pandemic providers that have emerged as top-runners in the ePharmacy space. The nature of services offered by these players can be viewed below. It is interesting to note that unlike MedPlus Mart, PharmEasy and Netmeds have not launched doctor consultation services (as of October 2022). Both offer diagnostic services.

Table 4 provides information on the key features offered by these ePharmacies. While we have attempted to add services that were available in the pre-pandemic market, some services might have been added during the pandemic or post-pandemic. The same have been explained below:

(i) Upload prescription: allows consumers to upload a valid prescription. The validity of prescription is predefined by the ePharmacy.

(ii) Request out of stock drug(s): allows consumers to request out of stock drug(s) by clicking a "notify me" option — when the drug(s) is available, the ePharmacy notifies the consumer on their shared email/phone number.

(iii) Online consultation with doctor/healthcare professional: allows consumers to connect with doctors via chat, audio or video consultations. For ePharmacies, the scope of these consultations can be limited. Eg: in case of an invalid prescription, PharmEasy offers doctor consultation, where the doctor calls the consumer and can provide them a valid prescription for their concern. The order is not completed without a valid prescription.

(iv) Availability of alternatives: allows consumers to view alternative drugs that treat the same or similar concerns as the drug they are opting for.

(v) Info about drug(s): ePharmacies provide information on the drug(s) and its components. The extent of this information can vary – some pharmacies may also provide information about dosage, side effects, etc.

(vi) Tracks previously consumed items: allows consumers to view items (drugs, nutrition supplements, fitness products, etc) they have previously consumed/ordered.

(vii) Multilingual: ePharmacies provide services in languages other than English. This specifies provision of all services and features offered on the mobile application or mobile optimised website.

Table 4: **ePharmacy services launched in pre-pandemic period and their respective features**

Service	Upload Prescription	Request Out of Stock Drug(s)	Online Consultation with Doctor/ Healthcare Professional	Availability of Alternatives	Info About Drug(s)	Tracks Previously Consumed Items	Multilingual
Netmeds (2015)	Yes	Yes	Yes	Yes	Yes	Yes	No
TATA 1mg (2015)	Yes	Yes	Yes	Yes	Yes	Yes	No
HealthKart (2011)	No	Yes	Yes[1]	Yes	Yes	Yes	No
MedPlus Mart (2015)	Yes	Yes	Yes	Yes	Yes	Yes	No
PharmEasy (2014)	Yes	Yes	Yes	Yes	Yes	Yes	No
Jan Aushadhi Sugam (2019)	No	No[2]	No	Yes	No	No	Yes

Notes: 1. HealthKart offers consultations with dietitians and trainers; 2. Cannot request on the app. It may, however, be possible to request the nearest jan aushadhi kendras to provide information on availability

1.2.3 eConsultation

In the pre-pandemic era, prominent consumer-facing or direct-to-consumer eConsultation services were offered by private mHealth providers. Government-run eConsultations services were doctor-to-doctor or assisted telemedicine services that required patients/consumers to visit health centres that provided these services. In 2019, for instance, eSanjeevani was launched as a doctor-to-doctor telemedicine service available at government-run Ayushman Bharat-Health and Wellness Centres (AB-HWC). eSanjeevani AB-HWC employed a hub-and-spoke model. The AB-HWC acts as the spoke where a generalist or paramedic and patient would connect with a specialist or doctor at the hub. The hub could be a tertiary hospital, healthcare centre or medical college. The stated objective of these services was to "provide general and specialised health services in rural areas and isolated communities" (Press Information Bureau 2022).

As per our evaluation, the multilinguality of online consultations is limited largely to the consulting doctors' multilinguality.

However, the availability of the mHealth mobile apps in more than one or two languages is extremely limited.

This section includes mobile applications and mobile optimised websites that offer doctor consultation. As mentioned in section 1.2.2, consultation services are also offered by ePharmacies like MedPlus Mart, 1mg, PharmEasy and Netmeds. The eConsultation platforms covered in this section, however, (i) focus primarily on consultation services and (ii) do not provide pharmacy services. We assessed the availability of 7 mobile application or mobile optimised website features offered by these eConsultation platforms (refer Table 5). While we have attempted to add services that were available in the pre-pandemic market, some services might have been added during the pandemic or post-pandemic by the evaluated applications. The same have been explained below:

(i) Consumer health profile: eConsultation app/site collects information about consumer symptoms, related medical history, and relevant prescriptions or lab tests to understand the consumer's health profile prior to consultation.

(ii) Audio consultation: eConsultation app/site provides audio consultation option to consumers. Also specifies whether audio consultation is an in-app feature or requires external calling (can be offline or online).

(iii) Video consultation: eConsultation app/site provides video consultation option to consumers. Also specifies whether audio consultation is an in-app feature or requires external video calls (eg: WhatsApp video calling, Google Meet, FaceTime, etc).

(iv) Feedback for consultation: eConsultation app/site has a feedback feature where

consumers can drop reviews, comments or suggestions about their consultation experience.

(v) Search for local healthcare facilities: eConsultation app/site provides information on local/nearby healthcare facilities for in-person consultations.

(vi) Multilingual: eConsultation app/site provides services in languages other than English. This specifies provision of all services and features offered on the mobile application or mobile optimised website.

Table 5: eConsultation services in pre-pandemic period and their respective features

Service	Consumer Health Profile	Audio Consultation	Video Consultation	Feedback for Consultation	Search for Local Healthcare Facilities	Multilingual
Practo (2010)	Yes[1]	(If provided, in-app or external)	(If provided, in-app or external)	Yes	Yes	No
TATA Health (2018)	Yes	Yes (in-app)	Yes (in-app)	No	Yes	No
Apollo 24|7 (2013)	Yes	Yes (in-app)	Yes (in-app)	No	Yes	No
Lybrate (2015)	Yes	Yes (in-app)	Yes (in-app)	Yes		No
DocsApp (2015)	Yes	Yes (in-app)	Yes (in-app)	No	Yes (app suggests physical visits if required)	Yes[2]
MFine (2017)	Yes	Yes (in-app)	Yes (in-app)	No	No	No
Manipal Hospitals (2015)	Yes	Yes (in-app)	Yes (in-app)	No	Yes[3]	No

Notes: 1. Practo Drive allows users "to store and view their medical records online" (Practo, n.d.); 2. DocsApp mobile app and mobile optimised website are available in English and Hindi. The eConsultations would depend on languages known to consulting doctors; 3. Only Manipal hospitals

Apollo was among the earliest providers of digitised healthcare in the country and a prominent private partner of government-backed telemedicine interventions (refer section 1.1). In 2013, Apollo Hospitals launched its emergency mobile application – 24|7 Emergency Mobile App. The application could be used by registered users during a medical emergency. Consumers had to pre-register by adding personal details (contact details, blood type, etc) and select guardian(s). These guardians could be sent an SOS notification (along with the registered user's location) during an emergency using the application. It also included emergency contact numbers (like the Apollo emergency number) and a 'medical list' feature that provided a location-enabled list of nearby medical facilities (hospitals, care centres, pharmacies, etc). A month before the national lockdown in India in March 2020, Apollo Hospitals launched the more comprehensive, in terms of services provided, Apollo 24|7 mobile application in February 2020. For our evaluation, we have categorised the application as an eConsultation platform. However, it also provides pharmacy services. Features of the new application and mobile optimised website can be seen in Table 5.

Mfine's market position places the application and mobile-optimised website in the eConsultation category. At the time of launch, in 2017, MFine offered online doctor consultation services. The mHealth platform has since evolved and now (based on October 2022 assessment) offers lab testing and online pharmacy services. The platform provides a

'self-checks' service for self-evaluating the risk of developing or worsening chronic conditions like PCOS and diabetes. This evaluation is done through a chat-based questionnaire, post which a risk-report is shared with consumers along with advice to lower risk. The platform also offers health information and education through featured blogs. Features of MFine can be seen in Table 5.

Launched in 2010, Practo began its consumer-facing doctor discovery and appointment booking services in 2013. By 2015, Practo was among mHealth solutions that provided consumers online consultation services with verified doctors (Verma 2015). provides its consumers the option to browse through profiles of multiple doctors, including doctor qualifications, specialisations, consultation fees and other patient's reviews. This can fix the information problem of the healthcare market. Traditionally, consumers did not have the option to assess the quality of care and qualifications of the doctor prior to their first consultation with the doctor. Apps like Practo also increase price transparency by displaying different consultation fees for the same service – consumers can make an informed choice depending on what seems most affordable to them. 2015 also witnessed the emergence of Lybrate and DocsApp in the eConsultation category.

In addition to paid online consultations, Lybrate allowed consumers to raise free queries that would be addressed by doctors on a non-urgent basis (claimed time: 6 to 24 hours). These queries may be posted anonymously on Lybrate's 'Health Feed', which includes articles, for other consumers to view. The qualification and specialisation of the doctor(s), who answers a query, are visible to the consumers. Therefore, in theory, Lybrate does provide a safer alternative for raising health/medical queries compared to online platforms like Quora and Reddit. Whether or not an anonymous, free query can reduce initial consumer reluctance vis-a-vis online consultations requires further research.

Medibuddy, a digital healthcare platform, was started in 2013 and DocsApp, an online doctor consultation platform, was started in 2015. In June 2020, Medibuddy and DocsApp announced a merger to "offer a comprehensive platform to our customers that delivers on the promise of a digital healthcare future" (PTI 2020). In this section, we evaluate DocsApp – the pre-pandemic online doctor consultation provider. Medibuddy services are covered in the 'Pandemic Adoption' section (section 1.3). DocsApp provides consumers the option to pick a healthcare speciality (gynaecology, dermatology, etc) or medical concern prior to the eConsultation. Consumers can also share the nature of concern (optional). The doctor is then

auto-assigned based on the information shared by the consumer. Consumers can only view the profile (includes qualifications and consultation fee) of the auto-assigned doctor. As per our evaluation, DocsApp does not have an option for sharing consultation feedback. This is different from a Practo that offers consumers the option to browse through doctor profiles (including qualifications), consultation fee, and reviews shared by other consumers prior to picking a doctor of their choice for the eConsultation. DocApp, however, does claim that all doctors are "carefully selected and personally verified". The mHealth provider also claims that consumers can "save up to 60%" when consulting on DocsApp.

Launched in 2015, Manipal Hospitals mobile application has been categorised as an eConsultations provider. This is done because at the time of evaluation the mobile application did offer online consultation services with Manipal hospital doctors. However, it is important to note that the healthcare provider's eConsultation services were a pandemic development, beginning in August 2020 (Manipal Hospitals 2020). In the pre-pandemic years, the mobile application was an extension of Manipal Hospitals' offline services. Consumers could use the application for booking appointments with doctors at Manipal hospitals, make online payments, maintain and import their health records, get directions to nearest Manipal hospitals, contact Manipal Hospitals' emergency services, access latest health trends and tips, and provide feedback for services offered (Manipal Hospitals 2015). Therefore, the pre-pandemic Manipal Hospitals mobile application would fit better in the health information and education category.

TATA Health was a pre-pandemic mobile application (and mobile optimised website) that offered doctor consultation, ePharmacy, and diagnostic services. TATA Health has been discontinued starting October 1, 2022. The reported reasons for end of TATA Health services included limited expansion since its launch and overlap with services offered by TATA-acquired 1mg (covered in section 1.2.2) (Zachariah 2022). Features of the TATA Health application are covered in Table 5. The application also offered home delivery service for medicines and free home pick up service from NABL accredited labs. TATA Health offered eConsultations in English, Hindi, Tamil, Malayalam, Telugu, Kannada, Bengali and Kashmiri.

As per our evaluation, the multilinguality of online consultations is limited largely to the consulting doctors' multilinguality. Some providers, however, have stated their intention to offer consultations in multiple Indian languages. For instance, in 2021, Practo announced that its doctors offered online consultations in 15 languages, including Hindi, Marathi, Kannada, Tamil, Bengali (Business Line 2021). The mobile application and mobile optimised website, however, are only available in English. Of the applications and websites we evaluated, only DocsApp was available in English and Hindi (all features and services were available in English and Hindi).

1.2.4 Health Data Storage and Tracking

(i) Health Data Storage: the app/site collects health and/or fitness related information. This may include provision to (i) upload medical records (prescriptions, lab reports, etc) and (ii) input information about diet, exercise, pre-existing health conditions, sleep pattern, menstrual cycle, sexual activity, etc.

(ii) Vitals tracking: tracks bodily vitals like blood pressure, heart rate, respiratory rate, blood glucose level, and body temperature.

(iii) Multilingual: the app/site provides services in languages other than English. This specifies provision of all services and features offered on the mobile application or mobile optimised website.

(iv) Additional features: the app/site offers services or features other than data storage and tracking. This may include, but is not limited to, online consultation services (with a doctor, nutritionist or fitness coach), articles/blogs on health trends and tips, etc.

Table 6: Health data storage and tracking apps in pre-pandemic period

Service	Consumer Health Profile	Multilingual	Vitals Tracking	Additional Features
Fittr (2016)	No	No	Yes	• Offers online consultations with fitness experts (may have additional charges) • Customised diet and fitness plans
Flo (2015)	Yes[1]	No	No	• Offers content on menstrual and sexual health (may have additional charges) • Provides consumers the option to turn on period reminder, contraception reminder, drink water reminders, etc. • Provides consumers the option to self log physical distress during menstruation (headache, cramps, etc.), moods, water intake, vaginal discharge, physical activity, oral contraception (OC) intake, non-OC pills, lochia (postpartum bleeding), pregnancy tests taken, basal temperature (helpful in predicting ovulation), and menstrual flow
HealthifyMe (2012)	Yes	No	No	• Provides consumers the option to set their fitness goal (eg: losing weight) – health information and education is offered accordingly • Tracks calorie and water intake • Has an 24*7 AI-based nutrition coach that answers basic consumer queries • Offers information through blog, Q&A, and workout videos • Offers paid subscription based fitness and nutrition plans (include audio consultations with fitness and diet coaches)
Google Fit (2014)	Yes	No	Yes	• Provides consumers the option to set their weekly activity goals (eg: 5000 steps per week) • Provides consumers the option to update daily calorie and water intake • Provides consumers the option to track their menstrual cycle • Can be connected with other fitness and health applications
My Health Record (2017)	Yes	No	Yes	• Provides consumers the option to maintain their own and their family members' health records (includes the option to upload prescriptions) • Provides consumers the option to track activity (cycling, swimming, walking, running) • Provides consumers the option to share their health records

Note: 1. Flo provides consumers the option to input and track their menstrual cycle, behaviour changes around menstruation, sexual activity, etc.

Based on our evaluation, health tracking and storage applications in the pre-pandemic era were largely focused on the promotion of good health. Features like vital tracking and physical activity logs were common to the applications we evaluated.

Fittr and Healthifyme cater to individuals who wish to actively engage in getting fitter. Both Fittr and Healthifyme offer online fitness services and provide consultation options. These consultations are with nutritionists and fitness experts. Largely, the business model of such applications includes both free and paid services. Free services include features like vital tracking, calorie intake log, water intake log, and physical activity tracking. Fittr and HealthifyMe also offer free of cost health information and education content (some content may be chargeable). The content is also focused on promotion of good health (eg: a blog on ways to reduce the risk of cardiovascular disorder). Paid features of Fittr and HealthifyMe include their subscription based packages that offer customised services like online consultations (audio consultations may be offline) with a personal trainer, customised diet plans, etc.

Google Fit is different from Fittr and HealthifyMe. It is only focused on data tracking and storage, and does not offer online fitness content or customised services. Google Fit provides consumers the option to turn on activity tracking, which allows the application to track metrics like steps taken and distance walked by the consumer. Additional features of the application are mentioned in Table 6. MyHealthRecords, provided by the National Health Portal - MoHFW, offers some similar services. It also provides consumers the option to track their vitals and maintain a physical activity log. However, the market position of this application is not that of a fitness application. MyHealthRecord allows consumers to maintain their electronic health records in one place. Unlike other evaluated applications in this category, MyHealthRecord provides consumers the option to upload prescriptions. These electronic records can be maintained for multiple individuals. A stated intent of the application is to increase portability of health data and enable better interaction between patients and healthcare providers. The application aims to reduce patients' burden in terms of paper-based record keeping (National Health Portal 2017).

We also evaluated Flo, a menstrual health tracking application. While Google Fit also provides consumers the option to track their menstrual cycle, this application adopts a specialised approach to menstrual, sexual and reproductive health of women. Primarily, Flo is a menstrual cycle tracking application. Consumers can use this application to track their menstrual cycle. Based on the information inputted by the consumer, Flo predicts the dates for the consumer's next period and their time of ovulation. However, the application offers multiple additional services, including tracking of mood swings, water consumption, exercise and content on sexual and reproductive health (refer Table 6).

1.3 Pandemic Adoption

Our conversation with TATA 1mg suggested an increase in demand for mHealth solutions during the lockdowns and the demand is continuing to see an upward trend compared to pre lockdown levels.

This section focuses on mHealth solutions that were either (a) launched during the pandemic or (b) gained prominence and scaled services during the pandemic.

Increased demand for consumer-facing mHealth solutions during the pandemic and lockdowns led to the expansion of these solutions. The most prominent example was the launch of MoHFW's eSanjeevaniOPD services during the pandemic, in April 2020. eSanjeevaniOPD, unlike eSanjeevani AB-HWC, does not require AB-HWCs. During the first nation-wide lockdown in India, the need for a direct-to-consumer telemedicine solution was realised. eSanjeevaniOPD is a patient-to-doctor solution that provides outpatient services (that do not require hospitalisation). Following the same model as that of eSanjeevaniOPD, the beta version of SeHAT was launched in August 2020. SeHAT provides patient-to-doctor online OPD consultation to serving armed forces, veterans, and their families. In May 2021, SeHAT OPD was developed by the Department of Military Affairs (DMA), Armed Forces Medical Services (AFMS), Integrated Defence Staff (IDS), Centre for Development of Artificial Computing (C-DAC) Mohali. A similar example is that of Online Registration System (ORS) teleconsultation services. ORS was launched in 2015 by the Central government. The pre-pandemic model aimed at providing an online platform to consumers for booking appointments at public health facilities (one could also book appointments at Central hospitals like AIIMS Delhi) – these online registration were expected to speed up the consultation process (The Economic Times 2016). During the pandemic, in June 2020,

AIIMS Delhi resumed consultations with great precaution through teleconsultation services. Appointments for the same could either be booked through AIIMS teleconsultation helpline numbers or through the ORS website (Saxena 2020). Today, the ORS website provides the option to book teleconsultation appointments at multiple hospitals, across Indian states. ORS does not have a mobile application (as of Oct 2022), but the website does have a mobile optimised version.

Locating diagnostic centres and checking test availability was a time-consuming task prior to the launch of the mHealth solution.

Source: The Hindu

The pandemic experience also led state governments to initiate or scale mHealth interventions. For instance, Telangana Diagnostics Programme was launched in 2018, with the aim to reduce out of pocket expenditure on diagnostic services for the poor. In May 2022, Telangana government launched T-Diagnostics, a mobile application aimed at improving access. According to a report by The Hindu, locating diagnostic centres and checking test availability was a "time-consuming" task prior to the launch of the mHealth solution. T-Diagnostics provides a list of nearest diagnostic centres based on consumers location. It also allows consumers to view the availability of different pathology and radiology tests — "The choice will take one to another page that lists out diagnostic centres according to distance, timings, available tests, option to check the maps for routes and contact numbers. The process that has to be followed to undergo the tests is also explained" (Shanker 2022). Uttar Pradesh's AYUSH department launched the AYUSH Kavach mobile application in 2020, amidst the pandemic. Based on traditional Indian health systems – Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy – AYUSH Kavach offers consumers health information and education. This included tips and tricks on stress management and information on immunity boosting nature resources that are easily available in UP.

We also noticed a trend of expansion in services by private mHealth providers. Launched in 2013, Healthians offered diagnostic services in 85 cities. In 2021, Healthian CEO, Deepak Sahni said, "There couldn't be a better time than today to launch Healthians' 'At Home' diagnostic model in 100 new cities across the country" (Venugopalan 2021). Our conversation with TATA 1mg also suggested an increase in demand for mHealth solutions during the lockdowns and the demand is continuing to see an upward trend compared to pre lockdown levels. Medplus Mart, focused primarily on online pharmacy services pre-pandemic, now offers online doctor consultations and diagnostic services. Medibuddy, a pre-pandemic era mHealth solution, merged with DocsApp, in June 2020, to offer multiple healthcare solutions – eConsultations, pharmacy services, and diagnostic services.

In 2021, a Hyderabad-based healthcare startup launched its mHealth application, Healpha. The application offers services to doctors and patients. Doctors can digitise healthcare services – manage digital payments, manage patient records, share e-prescriptions and e-reports, etc. As a consumer-facing application, Healpha has adopted an interesting model. In addition to offering online consultation services, the application allows corporates, schools and communities to book health screening (or preventive care) packages online. Corporates can book these services for their employees, schools can book them for their students, communities (like resident welfare associations, religious groups, etc.) can book services for their members. These offline health screenings are coupled with online services like continued care through online consultations, maintenance of electronic health records, e-prescriptions, and health cards (part of the community health package where services are being provided for a large number of members). Healpha also offers "remote/Covid homecare" service.

Healpha's model is an online-to-offline (O2O) model. While eConsultations can improve access to doctors, healthcare requires robust offline services. mHealth, in this case, can act as an easy-to-access facilitator. Below are some pandemic-era mHealth applications/sites we evaluated.

1.3.1 eConsultation

Table 7: **eConsultation services in pandemic period**

Service	Consumer Health Profile	Audio Consultation (If Provided, In-app or External)	Video Consultation (If Provided, In-app or External)	Reviews on Consultation	Search for Local Healthcare Facilities	Multilingual	Additional Features
NH Care (2020)	Yes	No	Yes (in-app)	No	Yes	No	• Provides consumers the option to book offline consultations at Narayana Hospitals • Provides consumers the option to upload and maintain their health records • Offers an online expert opinion service focused on cancer care; consumers can book expert advice and oncology analysis at home • Provides consumers the option to book lab test at Narayana or other partner hospitals
Proactive for Her (August, 2020)	Yes	No	Yes (external)	Yes	No	No	• Offline clinic for booking offline lab tests, HPV vaccines and other services in one location (Bangalore, Karnataka) • Book lab tests and HPV vaccine appointments • Provides written content on sexual reproductive health education • Provides video content on sexual & reproductive health, available on social media platforms like Instagram and YouTube.
Amaha Health (300% increase in downloads in 2021)	Yes	Yes	Yes	No	Yes	No	• Offers a mood tracker • Offers courses (eg: course for managing anxiety), exercises/ activities to improve mental health (eg: 15 activities to manage your emotions) • Has a learning hub with expert reviewed content on mental health (eg: understanding signs of depression) • Amaha community: safe space to connect with individuals on the mental health journey

Some pandemic-era mHealth solutions were difficult to categorise into the four categories for this study. For instance, Proactive for Her has been categorised as a Pandemic-era eConsultation service, but its market position is not necessarily only that of an online consultation service. The mHealth platform offers multiple health solutions for women's sexual, menstrual and reproductive care needs. Their diagnostic services, focused on preventive care services (like HPV vaccines and STI screening packages), might be equally important to their market positioning. The mHealth platform also provides health information and education content on sexual, menstrual and reproductive health. For the purpose of our evaluation, therefore, we have categorised mHealth solutions based on which of the four categories fits their market position best. Proactive for Her does not have a mobile application (as of October 2022), and operates through a mobile-optimised website. Our conversation with the founder of Proactive for Her revealed that a majority share of their website users were mobile users, i.e., majority of users were accessing their website on their smartphones. Additional features of the platform are mentioned in Table 7.

Unlike Proactive for Her and NH Care, Amaha Health (formerly Innerhour) was not launched during the pandemic but can be classified as a pandemic-era application. This is because the mental health-focused mobile application witnessed a 300% increase in downloads in 2021. Founder & CEO also said that majority demand was noted from tier-2 and sub-tier-2 cities (Ahaskar 2022). In addition to online consultations with therapists and psychiatrists, Amaha mobile application offers self care services. Consumers can pick their mental health concern (eg: anxiety), take an expert-made assessment, learn more about their mental health concern, get a personalised activities plan, and track their progress. Psychiatrists and therapists available on the mHealth platform come with detailed profiles, including their medical qualifications, area of expertise, consultation fee, and languages known. Some profiles may also include a video message from the therapist or psychiatrist. Additional features of the platform are mentioned in Table 7.

A study published by the Indian Society of Psychiatry found that 40.5% of respondents reported either anxiety or depression, 71.7% reported poor well-being, 74.1% reported moderate levels of stress, owing to the pandemic and lockdown situation in India (Grover et al. 2022). One study stated that the percentage increase in clinically significant anxiety and depression disorders was 35% in India (Singh and Sagar 2022).

1.3.2 ePharmacies

Table 8: ePharmacies in pandemic period

Service	Upload Prescription	Request Out of Stock Drug(s)	Online Consultation with Doctor/ Healthcare Professional	Availability of Alternatives	Info About Drug(s)	Tracks Previously Consumed Items	Multilingual
Flipkart Health+ (2021)	Yes	Yes	No	Yes	Yes	Yes	No
Aayu: medicine home delivery(assisted Rajasthan Govt in 2020) Rajasthan Govt in 2020)	Yes	Yes	Yes	Yes	Yes	Yes	Yes[1]

Note: 1. All app features and services available in Hindi and English

In financial year 2021, India's ePharmacies market stood at US $344.78 million

Source: Research and Markets

Indian e-commerce firm Flipkart acquired sastasundar.com in 2021. Sastasundar.com, an online pharmacy launched in 2013, is now Flipkart Health+. The market position of this pandemic-era mHealth platform is that of an ePharmacy. Flipkart Health+ does not offer online consultation or diagnostic services. A November 2021 report suggested the platform might expand to consultation and diagnostic services in the future (Dogra 2021).

Unlike Flipkart Health+, Aayu: medicine home delivery (hereinafter referred to as Aayu) was not launched during the pandemic. The application, developed by digital health startup MedCords, gained significant relevance during the pandemic. In 2020, Aayu partnered with the Government of Rajasthan to aid at-home delivery of essential medicine amid lockdowns. The primary idea behind this partnership was to ensure medicine delivery for the elderly, disabled and/or patients with chronic illnesses. MedCords also has an online doctor consultation application called Sehat Saathi. The Rajasthan government employed both applications for digital healthcare delivery during the pandemic (Healthcare Radius 2020).

1.3.3 Health Data Storage & Tracking

Table 9: Health data storage & tracking in pandemic period

Service	Consumer Health Profile	Multilingual	Vitals Tracking	Additional Features
Aarogya Setu (April, 2020)	Yes	Yes	No	• Linked with eSanjeevaniOPD – offers online consultations with doctors • Tracks Covid-19 vaccination status; locates nearby hospitals, health centres, diagnostic labs, and blood banks • Provides helpline numbers – senior citizens helpline, mental health helpline, child helpline, and health ministry helpline • Offers a self assessment feature where users can answer questions to assess their Covid-19 status[1] • Provides users the option to create a digital health ID or Ayushman Bharat Health Account (discussed in next section)

Note: 1. Aarogya Setu notifies: "your [self assessment] responses will help our doctors and medical researchers work more effectively."

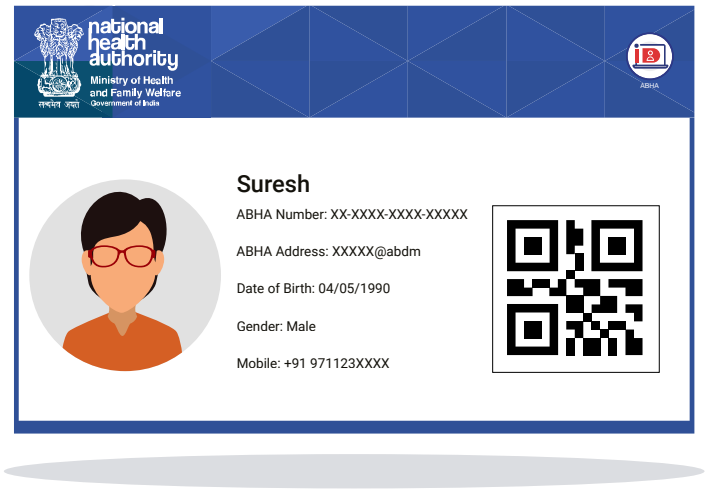
Aarogya Setu is among the most popular pandemic-era mHealth platforms. The application was launched in April, post the imposition of a nationwide lockdown in March 2020. The primary, stated function of the application was collecting relevant Covid-19 data through contact tracing. It records "details of all the people you may have come in contact with, as you go about your normal activities. If any one of them, at a later point in time, tests positive for COVID-19, you are immediately informed and proactive medical intervention is arranged for you" (Government of India 2020). An application like Aarogya Setu relies on a larger pool of users. During the pandemic, the Indian Ministry of Home Affairs made it mandatory for public and private sector employees to download the application to effectively manage Covid-19 spread through contact tracing (The Indian Express 2020). Additional features of the application can be seen in Table 9.

1.4 Future of Health-tech

Pre-pandemic, in 2018, NITI Aayog released the National Health Stack (NHS) document for consultation. The health stack was explained as a digital infrastructure or a set of building blocks for enabling digital health services. Components of the NHS included electronic health registries, coverage and claims platforms, a federated personal health records framework, a national health analytics platform, and horizontal components ("including, and not restricted to, unique Digital Health ID, Health Data Dictionaries and Supply Chain Management for Drugs, payment gateways etc shared across all health programs") (NITI Aayog 2018). A plan for implementation of the NHS was included in the J. Satyanarayana committee's National Digital Health Blueprint. In August 2020, during the pandemic, the National Digital Health Mission was launched, now known as the Ayushman Bharat Digital Mission (ABDM). The health stack has since seen greater clarity in terms of key building blocks (discussed in detail in chapter 2).

A clearly stated objective of ABDM has been to create a digital platform for healthcare delivery that allows for "interoperability of health data" and the creation of longitudinal electronic health records of citizens (Press Information Bureau 2022). To achieve this stated objective, the Indian government is now working on a Unified Health Interface (UHI). This is similar to Unified Payments Interface (UPI) that revolutionised the way Indians transfer money.

Through UPI the government provided the basic digital infrastructure needed for carrying out monetary transactions digitally. Through the UHI, it aims to create a similar federated digital infrastructure that allows circulation of health data. Health data, however, is more sensitive than monetary transactions. Consent and privacy, therefore, become crucial focus areas of the UHI. The NHA and/or ABDM discussions and webinars have indicated that the government is considering consent as a key aspect of the mission. The idea is to make sure consumers of healthcare own their health data, and can transfer the same to trusted healthcare providers or professionals. For consumers who lack digital literacy and/or access to smartphones, "assisted consent" is being worked on. The viability of assisted consent is still under work. One informant working with the NHA suggested that assisted consent is a crucial area of deliberation. (The technological aspects of UHI have been discussed in detail in section 2.4).



Source: National Health Authority, Ministry of Health and Family Welfare, Government of India

Likely Benefits of ABDM and UHI to different stakeholders

Benefits to patients

- Ease of discovering facilities, doctors, etc.
- Choice of providers
- Control over data
- Competing prices
- One place for all health records from various facilities - longitudinal health record

Benefits to doctors

- Access to medical history of the patient (better clinical care and prevent repetitive tests)
- Opportunity for professionals to serve remotely patients in aspirational districts, rural areas, etc
- Ease of discoverability

Benefits to policy makers

- Identify spread of resources and manage them efficiently
- Analyse the trends of symptoms, diseases, drug consumption (decision making facilitated, lockdown decisions, etc)

Benefits to health providers

- Vast troves of health data
- Reduces administrative burden
- Ease of doing business and easy discoverability
- Increased footfall

Benefit to health tech/startups

- Easy discoverability
- Leverage common public platforms
- Access to verified registries

Figure 2: Likely benefits of ABDM and UHI to different stakeholders (Adapted from 'ABDM #hackathon #masterclass' (AyushmanNHA 2022) and 'Digital India Week 2022 - India Stack Knowledge Exchange (Health Stack)' (Digital India 2022).

Some digital health solutions have already been onboarded as partners under ABDM, hence, signing up to become a part of the network-based digital health ecosystem. These include health-tech, Health Management Information System (HMIS), Labour Management Information System (LMIS), insurance, health locker and PHR digital health providers. So far the following health-tech players have become ABDM-enabled (October 2022):

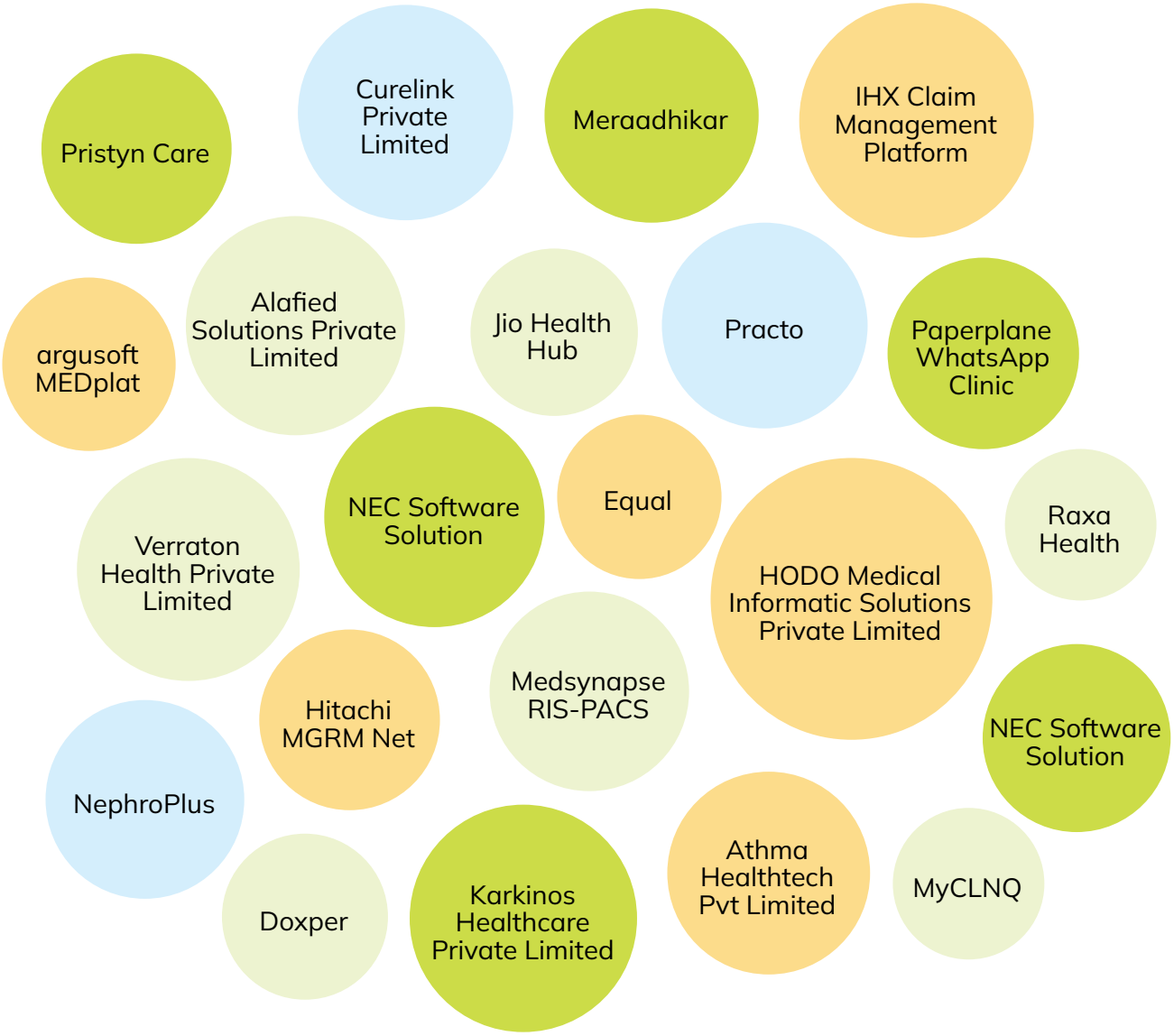


Figure 3: ABDM-enabled health-tech players (as on October 2022)

The digital healthcare sector and the many opportunities available for providers in this space have been time and again emphasised by Praveen Gedam (Additional CEO, National Health Authority), in the form of a matrix. Figure 4 is the matrix capturing these details of the features of healthcare service offerings that are possible to be provided:

Intersection of Opportunities Across the Health Domain

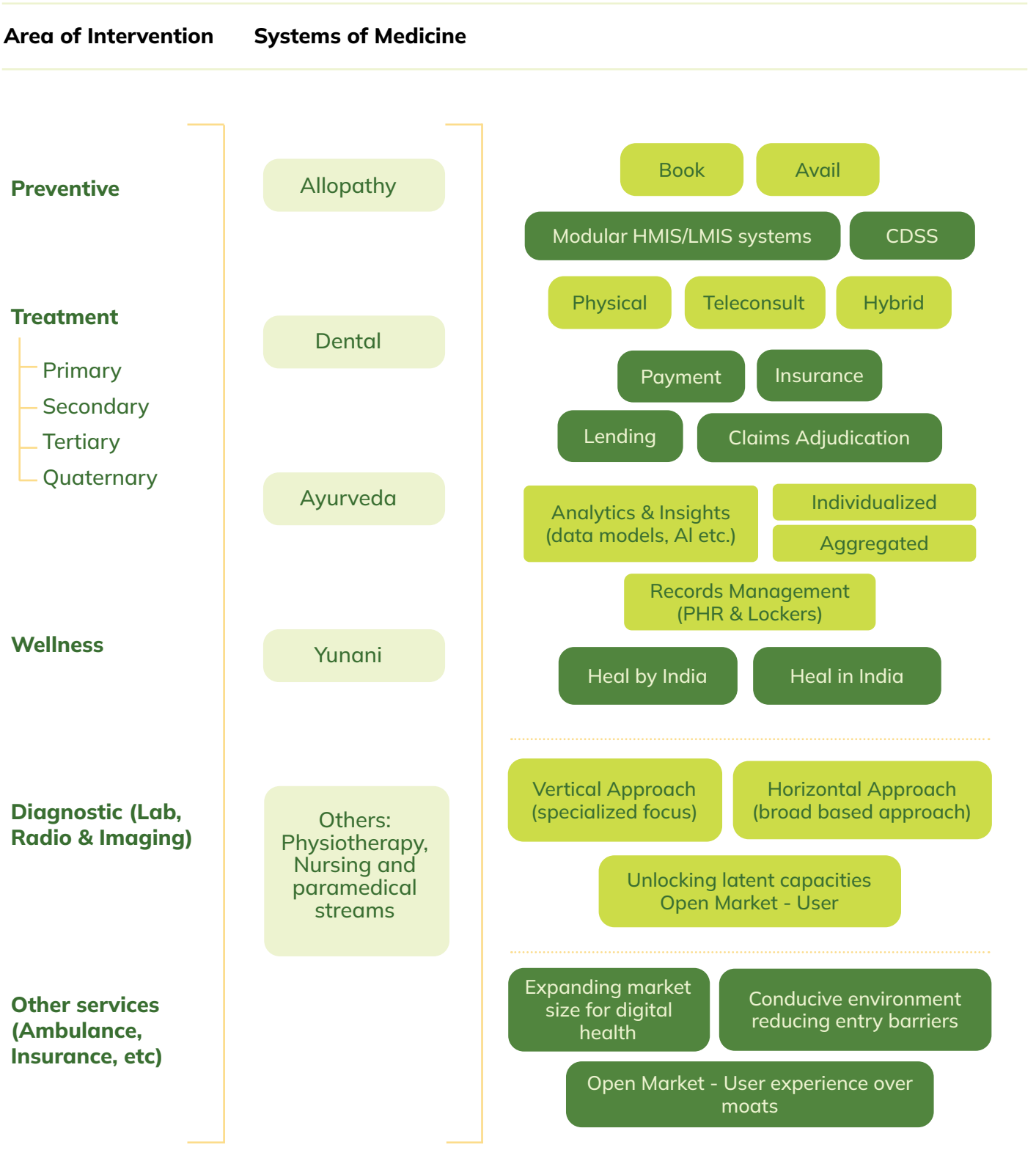


Figure 4: Intersection of opportunities across the health domain (Adapted from 'Dr Praveen Gedam talks about 'ABDM Opportunities for the Ecosystem' at NHA NASSCOM Conclave' (AyushmanNHA 2022)

Chapter 2

Tech-Fueled Access to Healthcare

Over the last few years, the role of information and communication technologies (ICT) in enabling access to healthcare has been increasingly appreciated and studied across the world. Voice calling, video calling, short messaging service (SMS), GPS and many other aspects of ICT have enhanced the mHealth services, which further continue to evolve. Instant sharing of information among healthcare personnel and patients, cloud storage of health data, easy dissemination of health information and health progress tracking are among the many uses of technology for enhancing access to healthcare.

While the use of SMS and other non-internet based services is not unheard of, the advancement of internet-based mHealth services is surely undebatable in this day and age. Internet enabled mobile devices with a high internet speed have become necessary to support the use of data intensive mHealth applications. In this chapter, we study the role and effects of technology in enabling access to mHealth services. We use the telecom lens to look into the mobile internet speed and experience provided by the top four telecom service providers (TSPs) in the country and compare it to the recommended standards for accessing mHealth services. The launch of 5G in India is expected to improve this access and experience for users. We discuss the potential changes India might see in the coming few years due to this 5th generation mobile network technology. Further, the concept of meaningful connectivity and India's current status and progress with respect to the same is discussed in detail. Lastly, we discuss National Health Authority (NHA)'s ambitious Ayushman Bharat Digital Mission and the plan to create a Unified Health Interface (UHI) for making healthtech interoperable and further enabling easy health information flow in India's health ecosystem.

2.1 Access Across India: The Telecom Lens

In India, 96.66% of internet users access the internet through mobile devices. As per TRAI data, although there are currently 639 internet service providers (ISPs) in the country, four telecom service providers collectively capture 98.29% of the market share—namely, Reliance Jio, Bharti Airtel, Vodafone Idea and BSNL. As of March 2022, the number of wireless telecom subscribers (or mobile phone subscribers) stood at nearly 1.14 billion (Telecom Regulatory Authority of India 2022). Of these, a majority share are smartphone subscribers. A Deloitte report suggested the number of smartphone subscribers are likely to swell up to 1 billion by 2026. This demand for smartphones is driven by the demand for internet-enabled services, including the demand for services such as telehealth (Deloitte 2022). In the last decade, India has witnessed a steady increase in the number of people accessing the internet through wireless data services. Given the large number of internet users accessing the internet through their mobiles, it also comes as no surprise that all four of these TSPs also capture 99.71% of the wireless subscriber base as top TSPs (Telecom Regulatory Authority of India 2022, 15, 39). The 4 TSPs are, thus, collectively capturing a huge majority of both, the telecom and the internet markets.

Wireless subscriber base market share across telecom service providers (TSPs) is as follows:

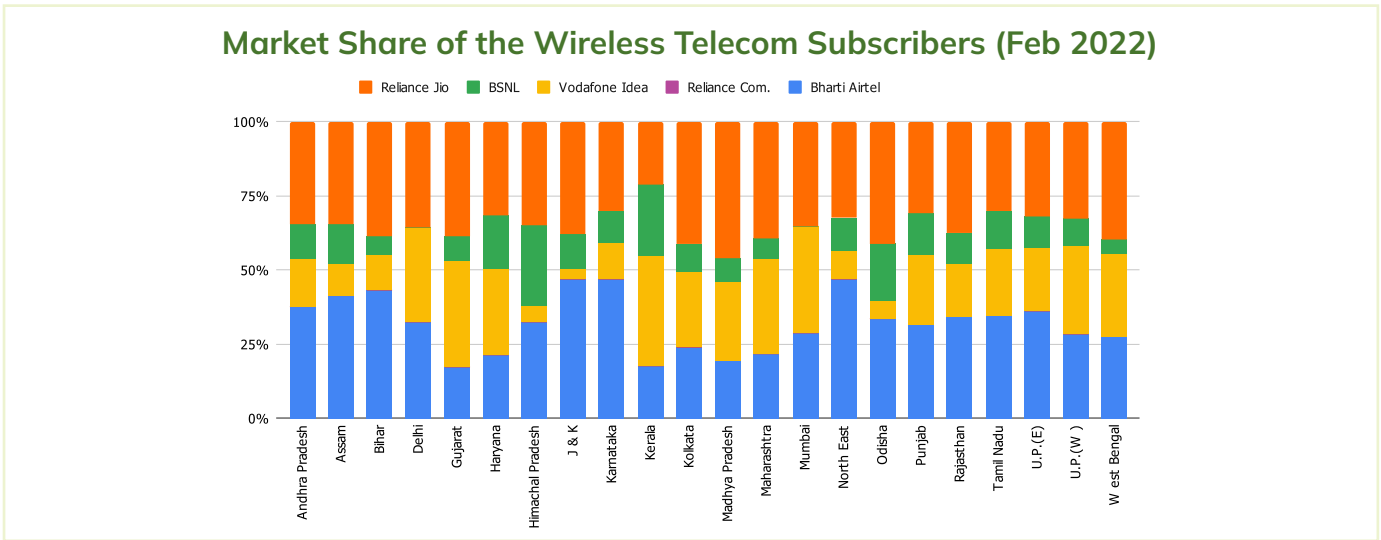


Figure 5: Market Share of Wireless Telecom Subscribers of TSPs as on 28th February, 2022 in the 22 telecom circles (Telecom Regulatory Authority of India 2022)

2.1.1 Broadband for India

Internet speeds are commonly understood to be either broadband or narrowband. Most internet users in India access broadband internet over their mobile devices rather than through a fixed broadband subscription. Definitions of broadband vary across geographies. TRAI consultation paper titled *'Roadmap to Promote Broadband Connectivity and Enhanced Broadband Speed',* published in 2020, discussed in detail the recommendations provided by different stakeholders regarding broadband in India (Telecom Regulatory Authority of India 2020). Further, in September 2021, keeping in mind the available technologies of 3G and 4G as well as the download speed requirement for basic applications, the Telecom Regulatory Authority of India (TRAI) recommended the revision of the **minimum broadband speed** to 2 Mbps (from the earlier minimum broadband speed of 512 Kbps) (Telecom Regulatory Authority of India 2021). It is pertinent to note that this is in sharp contrast with some of the standards followed in countries such as the United States where minimum broadband speeds are 25Mbps (download) and 3 Mbps (upload) since 2015 (Kruger 2017).

One may ask, why is the definition of broadband important and relevant to a discussion about access to mobile health services? Depending on how countries define broadband, the data on the number of people having access to 'high internet speed' changes. A claim about a certain percentage of population having access to 'broadband' doesn't tell us much about how many people of the country have meaningful connections that can aid access to the public services provided digitally. This percentage also does not tell us how many people have enough internet access to get on a video consultation call with their doctor or how many hospitals have enough internet to run their day-to-day operations through internet-based softwares and services. An unchanging and archaic definition of broadband is thus meaningless for analysing access of digital public services to citizens of a country.

2.1.2 First Steps to Access

Majority of mHealth apps studied are heavy in download size and require customers to have storage space as well as access to high speed internet for getting installation from an app store.

Different levels of internet speed, degree of video experience, internet-enabled voice calling and network coverage is required to meaningfully access various types of available mHealth services. These depend on several factors including the nature of a specific mHealth service being light, moderate or high use case. A large number of mHealth services require installation of an app from either google play store or apple app store or at times, GoI's mSeva AppStore. Our study showed that the majority of apps are heavy in download size and thus require customers to have storage space as well as access to high speed internet for installing the app from an app store.

Out of the total 38 mHealth services studied for pre-pandemic and pandemic period, 32 apps (on google play store) and 25 apps (on apple app store) had download size information available. On google play store, 22 out of these 32 apps are more than 10MB in size. Out of which, 3 apps are in the range of 20MB to 30 MB and 5 are above 30 MB and 4 are above 40MB. Poshan HealthPhone, the health information and education app by the Ministry of Women and Child Development is the heaviest app at 80MB. On the Apple app store, download size varies significantly. 22 out of the 25 apps are more than 10MB. Out of which, only 1 is in the range of 10MB to 20MB, 2 are in the range of 20MB to 30 MB, 11 are in the range of 30MB to 100MB, 5 are in the range of 100 MB to 200 MB and 3 are above 200 MB. Flipkart Health+ is the lightest and the only app out of the 25 apps available on Apple app store under 1 MB, at a mere 501.8 KB[1] . Ease of access to these apps, starting from installation to then the usage of different in-built features, to a large extent, becomes contingent on the user's access to a good internet speed.

In this context, Multi-access Edge Computing (MEC) has been considered as a solution. "Multi-access Edge Computing (MEC), defined as the ability to process and store data at the edge of the network, i.e., in the proximity of the data sources. The advantage of MEC in a smart health environment is multifold as it can provide short response time, decreased energy consumption for battery operated devices, network bandwidth saving, as well as secure transmission and data privacy" (Abdellatif et al. 2020). The access to online audio and video consultation features has been discussed in detail in section 2.1.3 and 2.1.4.

Mobile optimised websites can allow users to access several mobile app features without the need of installing or downloading, thus not occupying as much storage space. However,

1 For detailed information refer Annexure 1

these mobile-enabled website services are only accessible when the user is connected to the internet. It is pertinent to note, that certain mHealth services do not require access to the internet at all and are offered solely through SMS/IVR or telephone helpline numbers, as discussed in chapter 1 of this report.

2.1.3 Accessing Audio Consultation Services

As per the guidelines provided for Sub Health Centres (SHCs) within the Indian Public Health Standards (IPHS), for teleconsultations SHCs require a minimum bandwidth of 2 Mbps for last mile connectivity, which has often been argued as insufficient (Ministry of Health & Family Welfare 2022). This has been backed by arguments of traffic growth in the number of patients increasingly accessing teleconsultation services.

Given the shift to Voice over Wi-Fi (VoWi-Fi) and Voice over Long-Term Evolution (VoLTE) technology, users are increasingly using internet connections to make regular calls. VoLTE and VoWi-Fi allow TSPs to provide better network coverage and enhanced voice calling experience to its users. Assuming users of mHealth applications would only be running one activity during a time, the minimum data they require for such internet-based calling is less than **0.5 Mbps** (Kruger 2017). However, if users of mHealth apps are connected to household broadband where other family members of internet users are also connected at the same time, this minimum data requirement will go up significantly.

Audio consultations are a popular feature offered by mHealth service providers. In the Indian context, several of the consultation apps offer in-app audio consultation services. We use Opensignal data to analyse the likely experience users have while attempting to access audio consultation services of these apps.

Using open signal data on *in-app voice experience* in India across the 22 telecom circles, we found that **21 out of the 22 regions** have an '*acceptable*' level of in-app voice calling experience.[2] As per opensignal website, '*acceptable*' experience means that while these users experience some minor quality impairments, it is generally possible for them to communicate with each other without repetition. Call quality impairments are more frequent in the northeast region of the country (scoring 71.6 out of 100), falling well below the national average of 77.6 on a scale of 100. Metro and Circle A category regions report the best in-app voice calling experience, with Circle B category regions reporting marginally worse experience.[3] The following graph showcases the experience of users across circles (Khatri 2022).

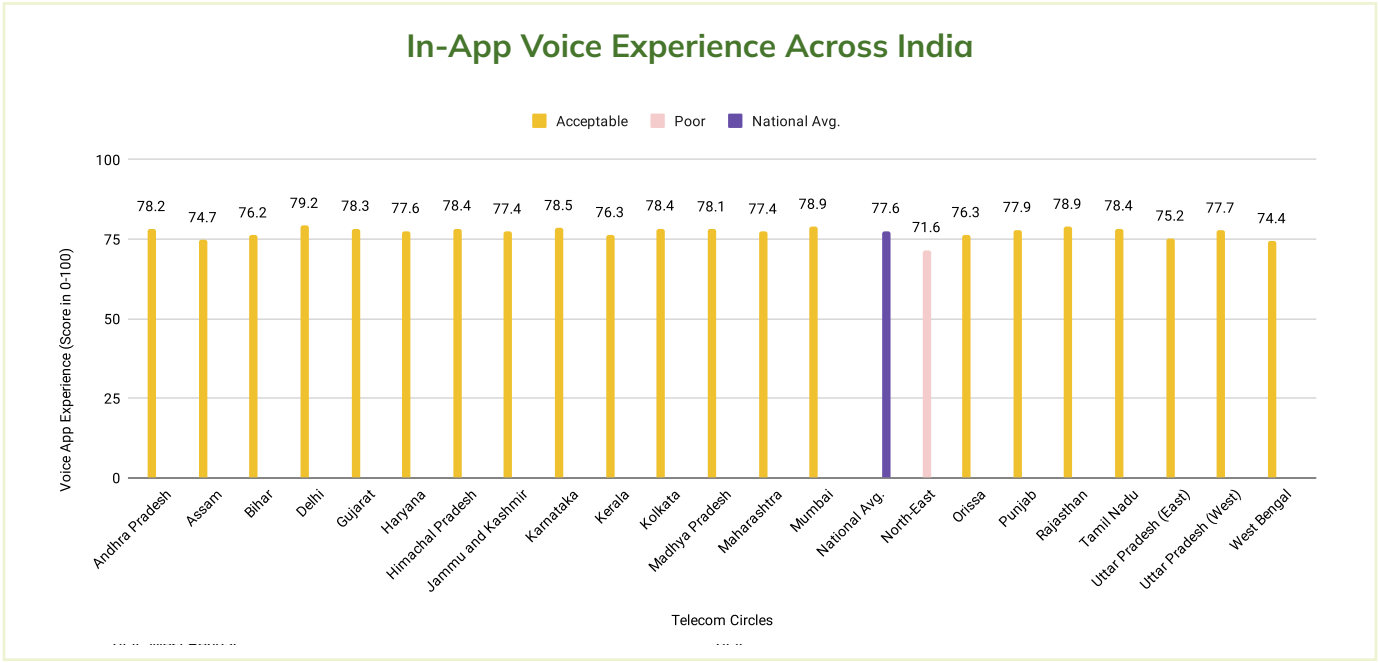
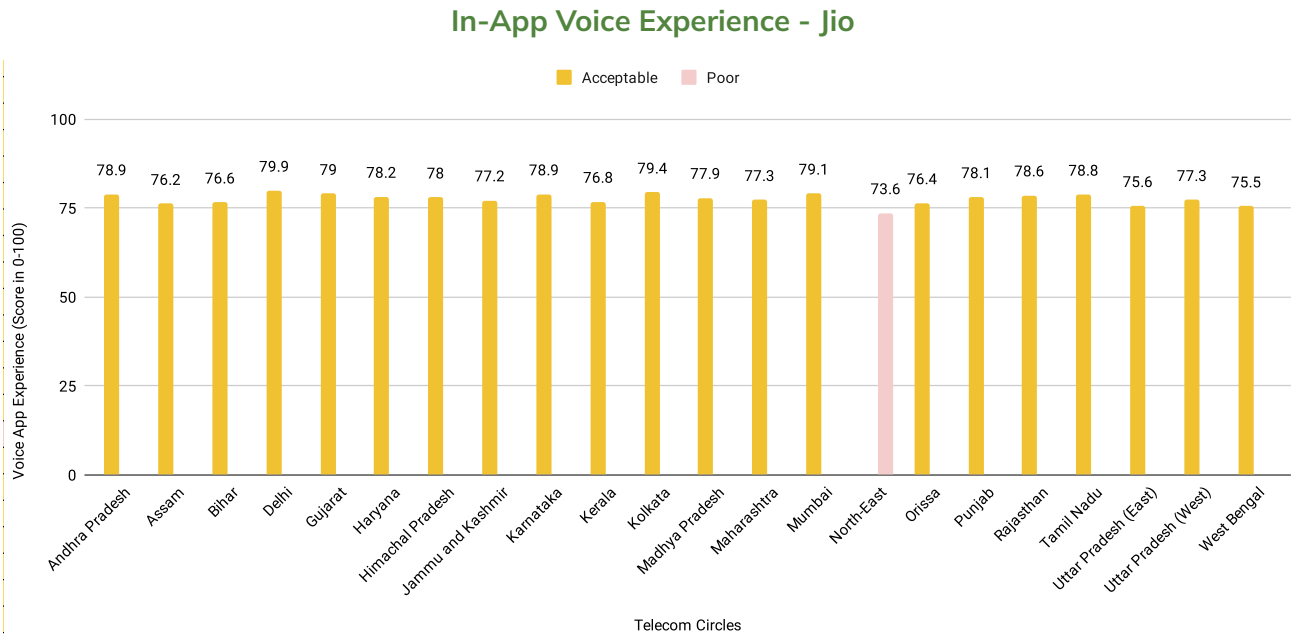
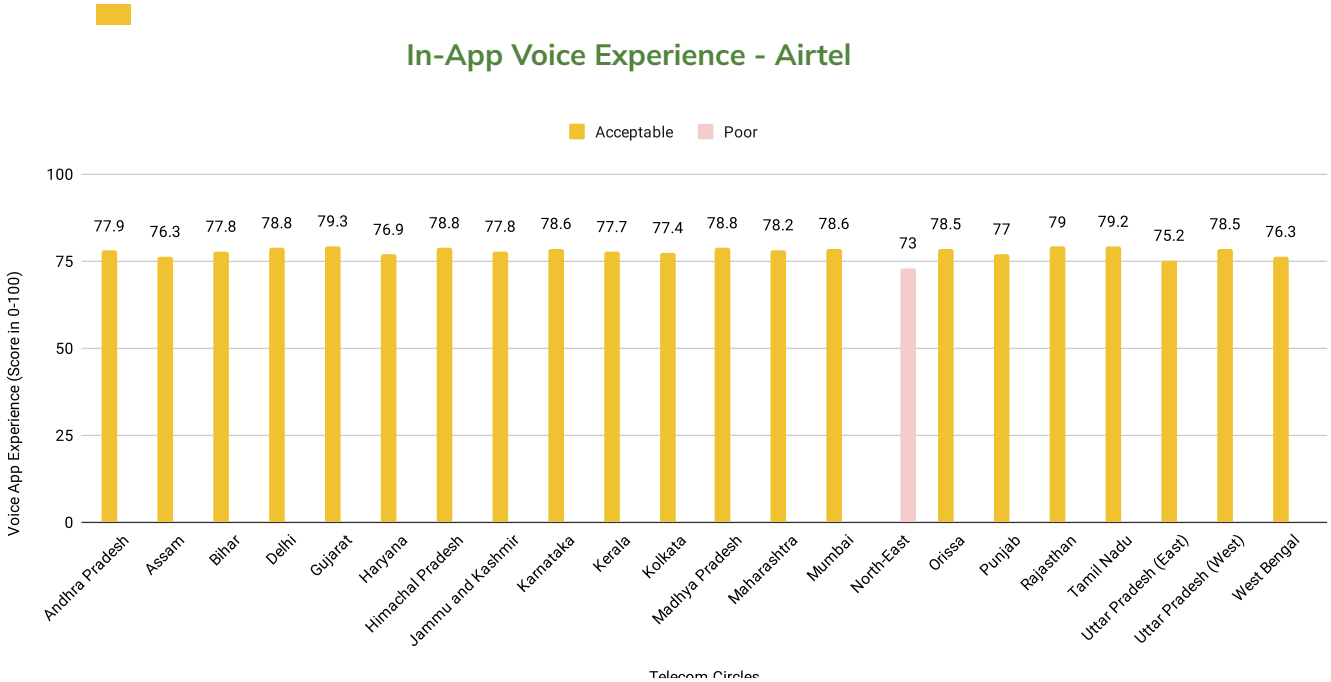


Figure 6: In-App Voice Experience across Indian Telecom Circles

2 Explanation of different levels of in-app voice calling experience has been provided in the annexure
3 Refer to Key Definitions and Concepts for information on categorisation of regions into various telecom

A closer look into service provider-wise data shows that out of the four TSPs, Airtel and Jio provided 'acceptable' in-app voice calling experience to its subscribers in 21 out of 22 circles, (North-East circle being the one exception). Subscribers of Vi in 20 out of 22 circles also had 'acceptable' in-app voice calling experience (North-East circle and Jammu and Kashmir circle being the two exceptions). Government-owned BSNL operates in only 20 of the 22 telecom circles and fares much poorly as compared to its counterparts. 8 out of its 20 circle subscribers have 'very poor' experience while the remaining 12 report 'poor' in-app voice calling experience.[4]





4 Service provider wise in-app voice calling data across the 22 regions can be found in the annexure.

Figure 7: In-App Voice Experience Provided by TSPs Jio, Airtel, BSNL and Vi across telecom circles

While HD video conferencing isn't impossible with the currently available internet speeds, the consistency and experience of video conferencing has been reported to be of poor-quality.

2.1.4 Accessing Video Consultation Services

While many platforms provide both audio and video consultation options, in certain cases the need for high-definition (HD) video conferencing/consultation is crucial. For example, a dermatologist examining a physical abrasion would preferably require HD video conferencing for examining the abrasion.

As discussed in chapter 1, video consultation with healthcare professionals is a key offering in many mHealth applications. For the purpose of video consultations, both patients and the doctor need a strong bandwidth connection. Only a few reports and papers discuss the required internet speed for using different video-based functions/applications. As per the report titled 'A new bandwidth prescription for healthcare', 4 Mbps is needed for HD streaming and 6 Mbps is necessary to support HD video conferencing (Spectrum Enterprise 2018). Another study gives a detailed description of network transmission speed in seconds for HD video conferencing assuming 1.9MBs of file size attempted to be accessed through speeds 4 Mbps (in 23.8 seconds), 10 Mbps (in 9.5 seconds), 20 Mbps (in 4.8 seconds) and 50 Mbps (in 1.9 seconds) (Srivastava 2020). Lastly, in an official report, as a response to recommendations submitted to TRAI, the regulatory authority quoted the United States Federal Communication Commission's broadband speed guide. As per the guide (refer Table 8), 6 Mbps is needed for HD video teleconferencing (Telecom Regulatory Authority of India 2021).

Table 8: Download speed for various applications

Application	Level	Minimum Download Speed (Mbps)
General Usage		
General Browsing and Email	Basic	1
Streaming Online Radio	Basic	Less than 0.5
VoIP Calls	Basic	Less than 0.5
Social Media	Basic	1
Telecommuting	Advanced	5 - 25
File Downloading	Advanced	10
Watching Video		
Streaming Standard Definition Video	Mid–range	3 - 4
Streaming High Definition (HD) Video	Advanced	5 - 8
Streaming Ultra HD 4K Video	Advanced	25
Video Conferencing		
Standard Personal Video Call (e.g., Skype)	Basic	1
HD Personal Video Call (e.g., Skype)	Basic	1.5
HD Video Teleconferencing	Mid–range	6

Source: Adapted from (Table 2.2 of TRAI publication 'Recommendations on Roadmap to Promote Broadband Connectivity and Enhanced Broadband Speed' 2021)

As per opensignal data, India has a **national average** of 13.1 Mbps download speed and 4.4 Mbps of upload speed (Khatri 2022). This is drastically below the 2022 goals set up in the National Digital Communications Policy 2018 that hoped to provide an average 50Mbps broadband connectivity to all Indian citizens. Moreover, under Broadband Highways of Digital India, provision of broadband connectivity will be done through three sub-

components: National Information Infrastructure, Broadband for All - Urban and Broadband for All - Rural. This is only one of the several ambitious goals set up by the government for broadband connectivity (Digital India, n.d.).

While HD video conferencing isn't impossible with such speeds, the consistency and experience of video conferencing need considerable improvement. Open signal data on video experience provides detailed insights on ***video experience*** across the 22 telecom circles (regions) of India, provided by the top 4 TSPs. As per opensignal report, customers report poor to fair video experience across all 22 telecom circles of India. On average customers across India have just above **poor-quality video experience.**[5] Customers in all 3 metro telecom circles - Delhi, Kolkata, and Mumbai have access to fair or poor levels of video experience. Jio, Vi, and Airtel subscribers in Delhi and Kolkata experience prolonged stalling and very slow loading times for higher resolution videos. However, the experience with lower resolution videos for some customers has been fairly sufficient. In Mumbai, Airtel customers experienced a poor video experience even for low-resolution videos while Vi and Jio customers faced stalling and slow loading mainly for high-resolution videos only. The situation in states categorised as circle A (Andhra Pradesh, Gujarat, Karnataka, Maharashtra, Tamil Nadu) is also fairly similar. Customers from regions of Himachal Pradesh, Jammu and Kashmir, North-East, and Orissa (Telecom Circles C) frequently experience a poor video experience even while streaming low-resolution videos. [6]

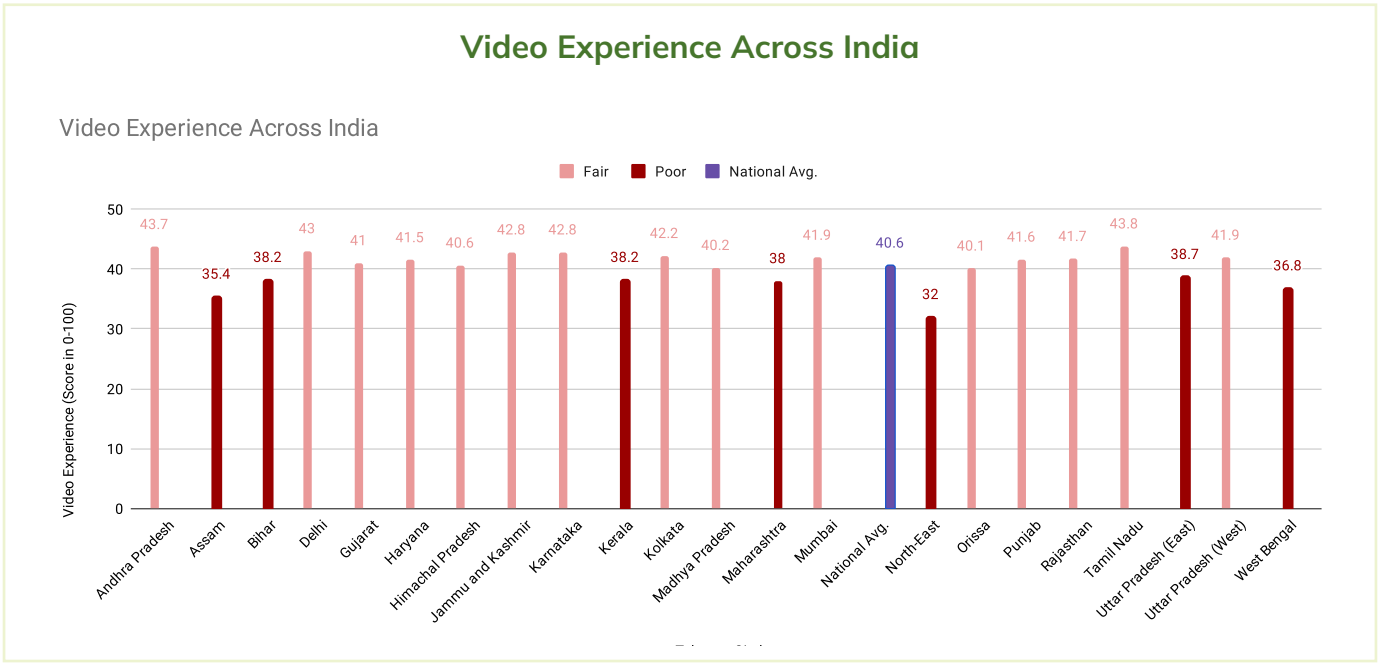


Figure 8: Video Experience across Indian Telecom Circles

BSNL customers experience extremely poor video experience across all the 20 telecom circles BSNL operates in. The lack of availability of 4G speeds on the network seems to be the reason for the same. With the launch of 5G, the BSNL customers who would choose to continue on the network are likely to have a wide gap in the speed and level of internet accessibility. Likely, such customers are mainly accessing voice-calling and non-internet-related services of the provider. In addition to the adequate speed of the internet, lower latency is also necessary for live streaming and video conferencing.

Based on the above data it can be inferred that though Indian mobile internet users can access basic levels of video consultations, their experience of the same ranges from fair to poor experience. For access to a high-quality video consultation experience, India surely needs to better its download and upload speeds, which currently stand at a national average of 13.1 Mbps (download speed) and 4.4 Mbps (upload speed) (Khatri 2022).

5 Explanation of different levels of video experience has been provided in the annexure (<40 is considered poor quality experience)

6 Service provider wise data on video experience is available in the Annexure 2

The role of telecom providers in increasing access to mHealth has been discussed, to some extent, by researchers across the globe. Apart from the role they play in ensuring a good quality of service through good data connectivity which is affordable and consistent, telecom providers can also play a potential role in providing infrastructure for cloud-based storage services as well as providing end-to-end system integration services. A report by Wipro Council of Industrial Research titled The mHealth Case in India discusses the same in detail (Lunde 2013). While Indian TSPs have been collaborating with healthcare and health insurance providers for some time now, Reliance group's Jio Health Hub is one of the distinctive examples of a TSP entering the consumer-facing digital health app market directly.

2.2 5G: A Game Changer?

In August 2022, 5G spectrum auction took place and soon after, the TSPs announced their plans for roll-out of their 5G services. Two months later, the launch of 5G services officially took place at the India Mobile Congress 2022. As compared to 4G, it is expected that 5G will have a manifold effect in decreasing latency and increasing speed (coupled with enhanced user experience). As per a blog by Airtel, 5G will allow users to access the internet 20 to 30 times faster, while latency is expected to go down from 50 milliseconds to as low as 1 millisecond (Airtel 2022).

The enhanced information transmitting speed supported by 5G will make the sharing and management of information faster among the various players within the digital healthcare ecosystem.

The enhanced information transmitting speed supported by 5G will make the sharing and management of information faster among the various players within the digital healthcare ecosystem. The benefits of 5G for healthcare will not be limited to mHealth. For instance, 5G-enabled smart ambulances are expected to be a boon for emergency care to be provided to critical patients, well before they even arrive in the emergency room (ER). The 5G technology shall also facilitate fast and reliable geo-location sharing for connecting smart ambulances with nearest critical patients and hospital's command centre. In this context, in April 2022, telco Bharti Airtel announced its partnership with Apollo Hospitals and tech-giant Cisco for creating 5G-enabled smart ambulances (Aulakh 2022). It comes as no surprise that telecom service providers are increasingly taking interest in the healthcare industry—important examples include Jio Health Hub (a consumer facing mHealth app) and Bharti Airtel's number of collaborations with Apollo Hospitals.

Network slicing is a fundamental capability of 5G that will be useful in enhancing user experience by allowing for efficient utilisation of network resources. "5G network slicing may make it possible to advance telemedicine in new areas of specialty by providing dedicated bandwidth for procedures requiring precision and millisecond interactivity, such as using robotics for heart surgery" (T-Mobile, n.d.). Particularly for mHealth users, access to high speed, low latency 5G network would imply enhanced audio and video consultation experience. Better connectivity and coverage through 5G for rural and remote areas of the country is also hoped to bridge the gaps that exist due to skewed doctor-patient ratios and poor physical connectivity between patients and hospitals. The overall smart health ecosystem shall also see a boost through enhanced connectivity on cloud-based platforms and better connectivity for patients and healthcare providers alike. As per ApolloTeleHealth CEO, Vikram Thaploo, 5G will also allow users to play an active role in managing their own wellbeing and health outcomes. It shall also enhance health data analysis significantly, "from diagnosis to emergency medical attention" (Thaploo 2021).

2.3 Meaningful Connectivity

The alliance for affordable internet (A4AI) has crafted a useful tool of "meaningful connectivity" for economies looking to become increasingly digitised. For a country's citizens to have meaningfully connectivity, they require to meet the four broad requirements/ benchmarks:

a. Being able to use internet regularly (daily use)
b. Having access to a smartphone device
c. Unlimited broadband
d. At least a 4G connection (or faster connection than 4G)

The alliance argues that the targets of meaningful connectivity must be adopted by policy makers and other authorities while analysing connectivity of citizens of the country (Alliance for Affordable Internet 2020). A mobile sample survey conducted by the alliance in India further showed that only an estimated 6.8% of Indians have 'meaningful connectivity'. The urban and rural meaningful connectivity for the country stands at 9% and 5.3% respectively, while meaningful connectivity of men and women turned out to be 9.8% and 3.3% respectively (Alliance for Affordable Internet 2022). [7]

The benchmark of 'meaningful connectivity' becomes particularly relevant for healthcare policymakers in context of India's ambitious plans of establishing an efficient and inclusive national digital health ecosystem, through its rapidly developing components within the Ayushman Bharat Digital Mission.

On 1st October, Prime Minister Narendra Modi in his speech at the India Mobile Congress 2022, talked about four key aspects to be focused on for a Digital India—digital connectivity, device cost, data price and digital first thought. These seem to be somewhat aligned with the concept of meaningful connectivity for India. Independent of the mobile survey results by A4AI, we discuss these four components in detail to understand how India currently fares on them:

1. Digital Connectivity

India has a Universal Service Obligation Fund (USOF), set up in December 2004, for providing telecommunication facilities to the remote and rural areas, in line with the Universal Service Support Policy. The fund status as on 31st August 2022, shows that only 53.26% of the fund has been disbursed by the government till date. However, the 'Universal Access Levy' contributions (collected as a percentage of revenue from telecom operators under several licences), have been steadily increasing over the last four financial years—from 2018-19 to 2021-22. [8] A report by GSMA, titled 'Taxing mobile connectivity in Asia Pacific', argues that the 5% of gross revenue from the TSPs would have been better utilised by the operators for infrastructure development and other useful investments (Sivakumaran 2018).

The National Broadband Mission, as charted out in the National Digital Communications Policy, focuses on universality, affordability and quality of broadband access. BharatNet, the government's broadband connectivity initiative for gram panchayats has been underway for several years but the uptake and implementation has been questioned by several industry players. This was also evident from the no uptake of public-private partnership (PPP) tender floated by the government for the same.

2. Device Cost

Goods and Services Tax (GST) on smartphones in India stands 18%, the second highest rate of GST to be charged of any category of goods, highest being 28% for luxury and demerit goods.

Having access to a compatible device is a non-negotiable requirement for having access to mHealth services. As per a global database on smartphone and feature phone device prices by A4AI, the cheapest smartphone at the time (Itel A23 PHantom by Reliance Jio), was 42.67% of the average monthly income in the country—Rs 4999. For feature phones, the JioPhone 2 was the cheapest option priced at Rs 2999—25.60% of the average monthly income in the country (Alliance for Affordable Internet 2021).

Taxation on devices further affects the price that a consumer needs to pay for a mobile device. Goods and Services Tax (GST) on smartphones in India stands 18%, the second highest rate of GST to be charged of any category of goods, highest being 28% for luxury and demerit goods. Custom duty levied on import of smartphones in India ranges from 10% to 15%, hoping to encourage the manufacturers within the country. A production linked incentive scheme offering an incentive of 4% to 6% to domestic mobile phone manufacturers on incremental sales was announced in April 2020 though a gazette notification (MeitY, n.d.).

The number of mobile phone manufacturing units in India is argued to have increased from 2 (in the year 2014-15) to 200 units (in the year 2020-21). As per reports, the increase in mobile production has been facilitated by the increase in import of mobile components from China. Moreover, reports suggest that this increase majorly caters to domestic demand since exports have still remained low (Krishnakumar 2022).

7 The detailed methodology and results of the survey can be accessed here https://a4ai.org/report/advancing-meaningful-connectivity-towards-active-and-participatory-digital-societies/

8 To know more about USOF, visit https://usof.gov.in/

Despite the low affordability of mobile devices in India, experts expect smartphone users to rise sharply. As per a report by Deloitte, in 2021, smartphones accounted for about 750 million out of the total mobile subscribers in the country. The study predicted that the number of smartphone users are further expected to reach 1 billion by 2026. It also predicts that this growth will be fueled by an increase in internet adoption, given the increasing need of adopting e-learning, fintech and e-health. Per the analysis, the average lifespan of a mobile device is 3 years in urban markets and is expected to become 4 years in rural markets as well—with a huge majority of mobile device replacements being new smartphones rather than pre-owned phones. The replacement rate of feature phones with smartphones will also decrease gradually as the number of overall smartphone users go up (Deloitte 2022).

3. Data Price

Data prices in India have seen quite an evolution over the years. The emergence of Reliance Jio, as a telecom provider offering extremely affordable data, has been attributed for the price war among TSPs, leading to the overall drastic fall in data prices in the country. However, the push for higher revenues, merger of Vodafone Idea and Airtel's resurgence as a player with the highest number of subscribers added in a period, are all factors that have affected the data pricing after 2016.

As per the *Worldwide Mobile Data Pricing* 2022 report, the average data price in India stood at $0.17, well below the global average of $3.12. The report attributes India's high dependence on (and demand for) mobile broadband services as one of the key reasons for low data prices.

Usually, in comparison with postpaid plans, prepaid plans are considered a marginally cheaper but restrictive option for data usage purposes (wrt to data limits) (Selectra, n.d.). Users relying on accessing the internet majorly through Wi-Fi connections may thus choose to opt for the latter. Ease of shifting to a different tariff plan in a pre-paid connection is also more.

As per the Worldwide Mobile Data Pricing 2022 report, the average data price in India stood at $0.17, well below the global average of $3.12. The report attributes India's high dependence on (and demand for) mobile broadband services as one of the key reasons for low data prices.

The average revenue per user per month in March 2022 was the highest for Bharti Airtel at $2.29 (Rs 178). The other two major telcos, Vodafone Idea and Reliance Jio reported $1.59 (Rs 124) and $2.16 (Rs 167.6) in ARPU per month respectively (Kaur 2022).

As of November 2022, the two leading TSPs in India, Jio and Airtel have announced their 5G tariffs and plans. Airtel has priced 5G plans the same as their 4G plans, however, as per reports, is likely to revise tariffs in a few months (Aulakh 2022). Whereas Jio 5G (both prepaid and postpaid) plans promise internet speed up to 1Gbps, starting at a price of Rs 239. Interestingly, as per a GSMA report, on an average, across countries 1GB of 4G network is more expensive ($13) than the 1GB of 5G network ($13). However, the higher speed consumption on 5G networks requires users to buy new packs more frequently (Pandey 2022).

4. Digital-first Thought

The government's intention to digitise several sectors is quite evident. The Union Budget 2022 also saw the announcement of budget allocations and setting up of many digitally enabled services and solutions across sectors such as education, banking and healthcare. The finance minister, Nirmala Sitharaman, announced the rollout of a National TeleMental Health Programme and the National Digital Health Ecosystem (Press Information Bureau 2022).

The health information exchange architecture and the upcoming unified health interface system is expected to further digital-first thought for certain aspects of the healthcare services given the interoperability of the system. The public 'health stack' will be usable by both Centre and State and by both public and private entities, facilitated by the digital public good of Unified Health Interface (UHI). Section 2.4 elaborates further on UHI and the Ayushman Bharat Digital Mission.

2.4 India's Digital Health Mission

The National Health Authority (NHA) is working towards building an integrated infrastructure for digital healthcare in India through its Ayushman Bharat Digital Mission (ABDM), earlier known as the National Digital Health Mission. Through this mission, the NHA hopes to provide Health IDs, create digital repositories of health professionals and health facilities and allow for easy sharing of health records, among other things, through a network-based ecosystem (differing from the current platform-based ecosystem).

2.4.1 Ayushman Bharat Digital Mission (ABDM) Features

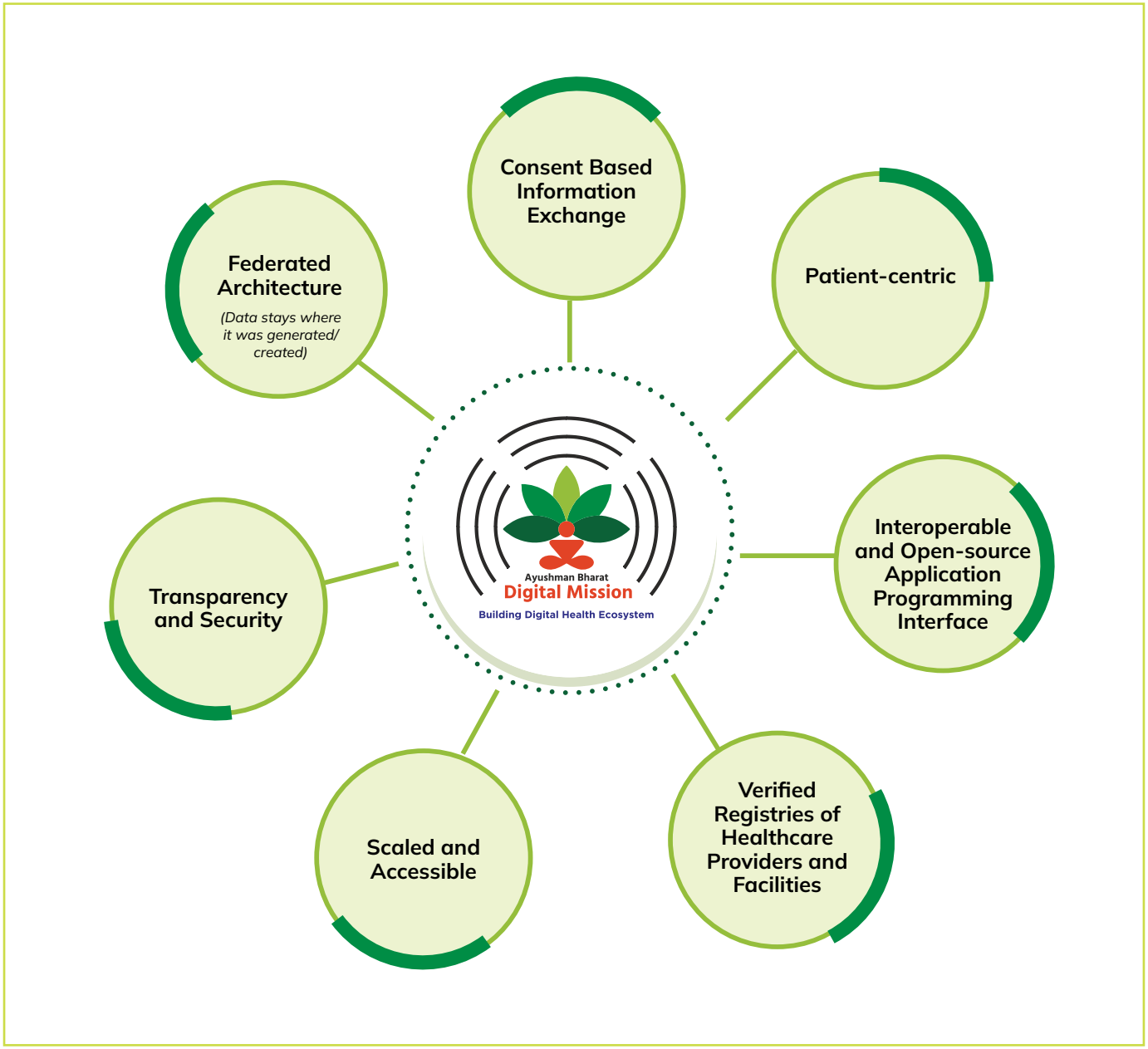


Figure 9: Features of the Ayushman Bharat Digital Mission (AyushmanNHA 2022)

2.4.2 ABDM Building Blocks

ABHA Number

Unique identifier for patient authentication and sharing of health records

Healthcare Professional Registry

Verified digital repository containing verifiable credentials

Health Facility Registry

Includes hospitals sub centers district level hospitals labs etc.

Personal Health Record (ABHA App)

ABHA App - reference application to demonstrate how the system shall facilitate the searching of facilities, viewing personal health records and sharing the same through a consent manager

Unified Health Interface (UHI)

Interoperable Network-based System

Figure 10: Building Blocks of the Ayushman Bharat Digital Mission (Ayushman Bharat Digital Mission, n.d.)

2.4.3 ABDM Stack

Simply put, a technology stack refers to "a set of technologies that are stacked together to build any application" (MongoDB, n.d.). With ABDM, the NHA is creating a 'health stack'—a set of building blocks for enabling digital health services in India. The ABDM stack, as it is now called, has the layer or cross-domain digital public goods of India at the bottom of the stack (refer Figure 9).

The Government of India has been working on creation of several digital public goods across different domains. Similar to the concept of public goods (in economics), digital public goods (DPGs) are also non-rivalrous and non-excludable in nature. The United Nations defines DPGs as "open source software, open data, open AI models, open standards and open content" (United Nations 2020). The cross domain DPGs in ABDM stack include Aadhar, UPI, e-sign, consent artefact, etc. The other layers of the stack include the health building blocks (digital registries, health records, health claims), unified health interface and the user applications.

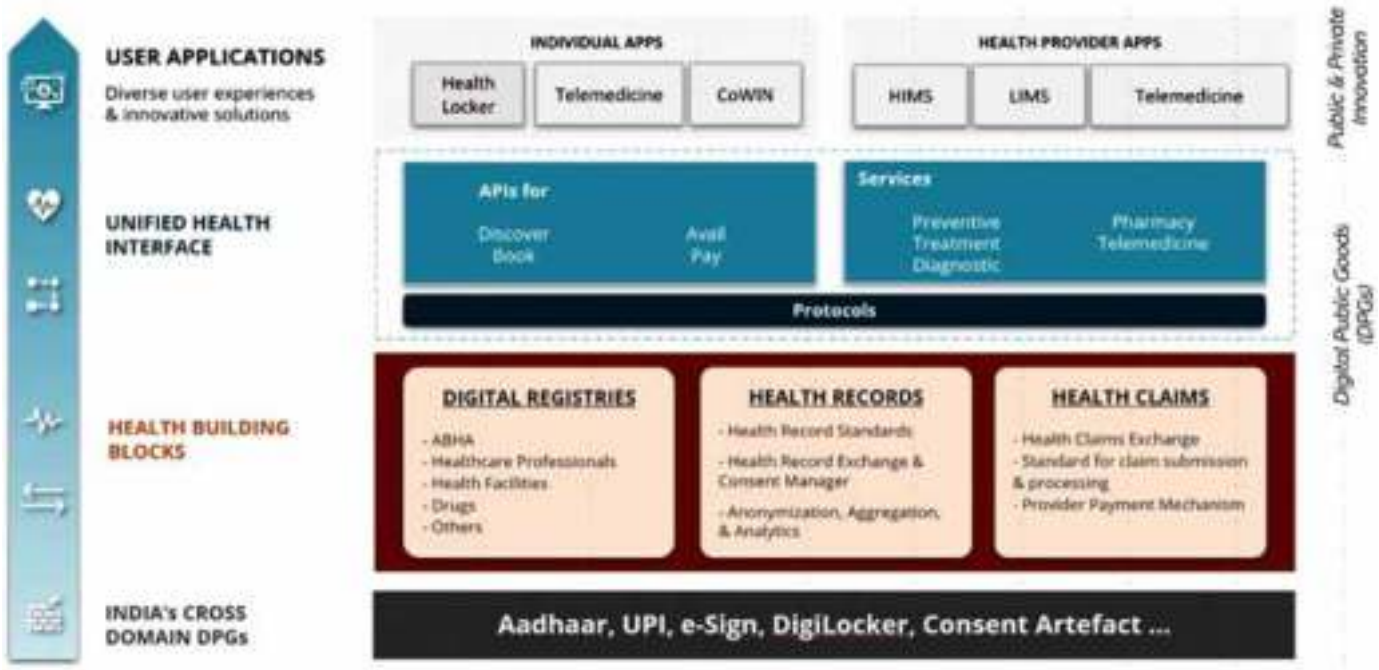


Figure 11: Ayushman Bharat Digital Stack, slide, in ABDM #hackathon #masterclass by AyushmanNHA 2022

A key component of this ABDM stack is certainly the Unified Health Interface (UHI)— "a network of open protocols that enable the interoperability in health services," and thus facilitate user access to various healthcare services through the user interface (UI) of the patient's choice ("What is UHI", n.d.). Currently, healthcare services exist in silos. Simply put, the interoperability facilitated by UHI will enable discoverability—users will be able to search any health service provider easily, irrespective of which end user application they are using. This will be facilitated through the digital registries (Health Facility Registry and Healthcare Professionals Registry). For example, someone using the Practo app will be able to search for healthcare professionals listed on other apps such as the eSanjeevaniOPD. This interoperability shall exist across web applications/web portals and mobile applications alike. UHI shall also provide consumers with 'verified providers' and 'transparency in pricing' (AyushmanNHA 2022). The UHI system is based on an open application programming interface (open API) that shall facilitate this interoperability of digital health solutions (Ayushman Bharat Digital Mission, n.d.).

The diagram below (featured in the UHI consultation paper by ABDM) is a pictorial representation of the current platform-centric model and the proposed open network-centric model (Ayushman Bharat Digital Mission 2021). [9]

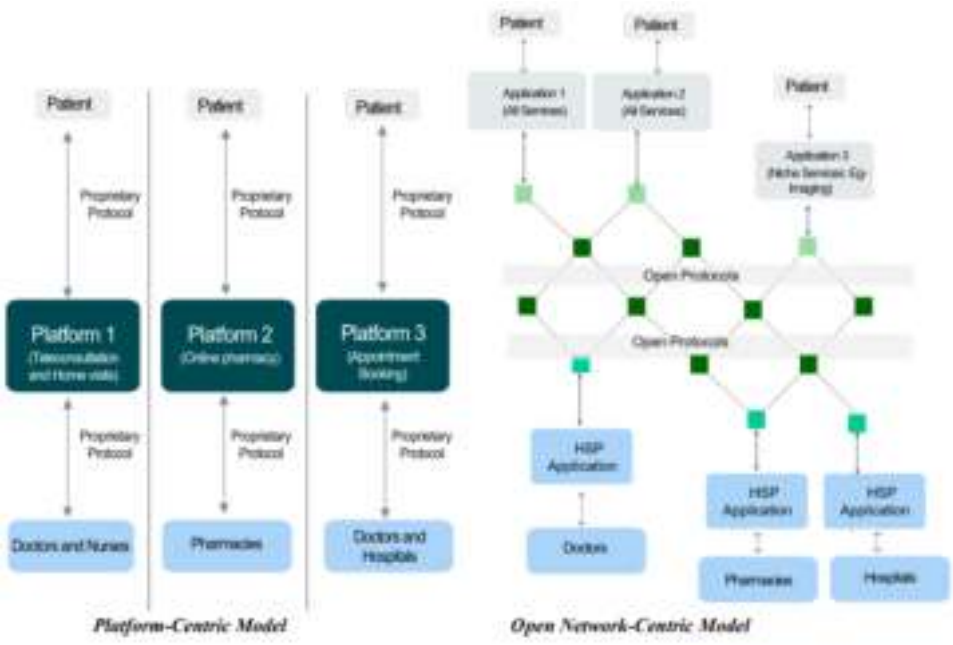


Figure 12: "Open Networks and Protocols", chart, in Consultation Paper on UHI by Ayushman Bharat Digital Mission 2021

The ABDM ecosystem will allow for a federated architecture to exist, where data will be stored in multiple places and no centralised repository will exist for healthcare records. As per the ADBM website, the storage system currently being used by a certain health care facility (or even healthcare user) will stay the same way. The only data that shall be stored centrally, will be the data that is captured through the various proposed health registries, as envisioned in the digital health system—Healthcare Professional Registry, Healthcare Facility Registry and Health ID Registry. This also implies that data retention policies of the healthcare providers will continue to apply, based on the service provider a user chooses to opt for. Additionally, the Ayushman Bharat Health Account (ABHA) will also allow users to view their longitudinal health records, capturing information from different healthcare providers within the ABDM-enabled ecosystem. Users will be able to access their longitudinal health records on their preferred mHealth user interface (Ayushman Bharat Digital Mission, n.d.).

The consent manager layer of the ABDM system is another key building block. Users shall be able to share a part of their electronic health records with their healthcare providers by providing their informed consent (and revoking it, whenever they wish). In April 2022, the NHA published a version 2 of the Draft Health Data Management Policy that goes into the detail of what the consent framework of ABDM shall be like and how it will be governed (National Health Authority 2022). ABDM promises to be secure, encrypted and inclusive. Assisted methods for using the platform are being put in place for users who lack digital literacy or access to suitable devices. However, how the consent for such users—likely to be assisted consent—will be managed securely remains unclear. The sandbox of ABDM also provides details of the federated health records framework, the health data consent manager and other building blocks that can be used by healthcare service providers, healthcare software vendors and anyone else interested in building on the architecture (ABDM Sandbox Environment, n.d.).

9 For more information on Open Protocol in context of UHI, read the full UHI consultation paper: https://abdm.gov.in:8081/uploads/Synopsis_Consultation_Paper_on_UHI_v_H_83b81ca1f7.pdf

Ayushman Bharat Health Account (ABHA) will allow users to view their longitudinal health records, capturing information from different healthcare providers within the ABDM-enabled ecosystem.

Users will be able to access their longitudinal health records on their preferred mHealth user interface.

The subject of consent is surely a sensitive and important one. Methods of self-service consent by a user vis-a-vis an assisted consent will likely vary in design. In this context, self-service consent refers to consent provided by the user independently, without any assistance i.e. the owner of the data easily opts-in or revokes or restricts their consent on their own.

The Digital Personal Data Protection Bill, 2022, introduced in November 2022, also addresses consent and deemed consent. With respect to situations relating to health, the deemed consent section in chapter 2 of the bill (Obligations of Data Fiduciary), states:

"A Data Principal is deemed to have given consent to the processing of her personal data if

such processing is necessary: .....(4) for responding to a medical emergency involving a threat to the life or immediate threat to the health of the Data Principal or any other individual;

(5) for taking measures to provide medical treatment or health services to any individual during an epidemic, outbreak of disease, or any other threat to public health;" (Ministry of Electronics & Information Technology 2022).

The National Health Service of the United Kingdom states that "for consent to be valid, it must be voluntary and informed, and the person consenting must have the capacity to make the decision" (National Health Service, UK, n.d.). The meaning of the terms voluntary, informed and capacity are further defined as follows:

"**voluntary** – the decision to either consent or not to consent to treatment must be made by the person, and must not be influenced by pressure from medical staff, friends or family

informed – the person must be given all of the information about what the treatment involves, including the benefits and risks, whether there are reasonable alternative treatments, and what will happen if treatment does not go ahead

capacity – the person must be capable of giving consent, which means they understand the information given to them and can use it to make an informed decision" (Ibid.).

In the digital health context, the ABDM ecosystem will require designing of the interface for users giving consent for digitally sharing their Personal Health Records with their healthcare service provider as well as the interface for healthcare providers to raise requests for consent to be provided. The design of how consent can be provided by users is likely to vary from a multimedia form of consent to an IVR call to an inbound SMS-based OTP.[10] Given that ABDM will also allow for revoking of such consent at any point in time, the same will have to be thought through for cases where assisted informed consent was taken from users with low digital literacy and/or no access to suitable devices (ProductNation/iSPIRT 2020). Learnings from early assisted telemedicine initiatives, that connected rural/remote populations to specialised health centres, can serve as reference for the types of issues that an assisted informed consent mechanism may have to tackle and take into consideration.

10 The National Health Stack open house conducted by iSPIRT on 30th May 2020 provided an outline of how the API bridges and consent manager mechanisms can be designed and what should developers look to innovate on, with respect to designing their systems (ProductNation/iSPIRT 2020). More information on Health Data Consent Manager and Gateway can be accessed on the ABDM Sandbox website. https://sandbox.abdm.gov.in/docs/cm_gateway

Chapter 3

Chapter 3: Usability & Acceptability

The adoption of a particular technology by users depends on its usability and acceptability. Usability and acceptability of a technology inturn depends on a variety of factors. Acceptability of a technology can be defined as the degree to which a user is willing/reluctant to use a particular technology. Whereas, usability for the purpose of this study, simply put, is based on the efficiency, effectiveness, and satisfaction perceived by a user of the technology.

Over the years, the Technology Acceptance Model (TAM) has emerged as a popular choice for understanding the ease of use and adoption of several technologies. The model can be used for assessing a range of technologies, including but not limited to hardware, software, applications, etc. Extensions and modifications to the model have been developed and used by researchers to suit the context and use case in question. For mHealth, extensive literature exists for adoption of the technology in regions of North America, South America, Africa and Bangladesh (Shaw and Rajak 2021). Study of usability and acceptability of mHealth apps in India has, however, been limited—both in the number of studies and their scope.

Technology Acceptance Model and its Popular Evolved Versions

TAM

External variables affect perceived usefulness (PU) and perceived ease of use (PEOU), with the PEOU also influencing PU to some extent – these two inturn affect the "attitude toward using" a technology (positive or negative attitude), which further leads to a user's "behavioural intention to use". A positive intention will lead the user to the "actual system use" or a higher likelihood of using the technology.

TAM 2

(or extended TAM) majorly breaks down the kind of factors that would affect the perceived usefulness of a technology and a user's intention to use. It adds aspects on subjective norms, job relevance, voluntariness, etc to the assessment (Davis and Venkatesh 2000).

Unified Theory of Acceptance and Use of Technology (UTAUT)

UTAUT

This revision of the TAM adds key factors to the assessment of the technology, such as social influence, performance expectancy, effort expectancy, gender, age, etc. Social influence in this context may originate from a close relationship of the user (such as friends and family members) or from an expert/influential individual in the domain or in general. Such influence may be positive or negative in its effect (Venkatesh et al. 2003).

UTAUT 2

This evolved model of UTAUT adds hedonic motivation, price value and habit to the assessment (Venkatesh, Thong, and Xu 2012).

In the context of consumer-facing (B2C) mHealth technology, we limit the scope of assessment to the usability and acceptability among the users/consumers of the service. Drawing from various models, including but not limited to TAM, we discuss some key factors affecting usability and acceptability of mHealth services. This is not an exhaustive list of factors and it must be noted that studies and models emerge and evolve to address the effect of factors that can affect usability and acceptability of mHealth among a group of consumers. The factor of affordability has largely been left out from the scope of this report as it requires a sophisticated in-depth context specific and up-to-date study, given

its dynamic nature and relation with multiple other factors. However, mHealth affordability in the context of technology required for accessing mHealth (with respect to device and data cost) has been briefly discussed in chapter 2. Additionally, factors such as proximity of users to the physical infrastructure, app user interface, quality of life and interoperability of platforms (as envisioned by ABDM) provide scope for future research on this important topic.

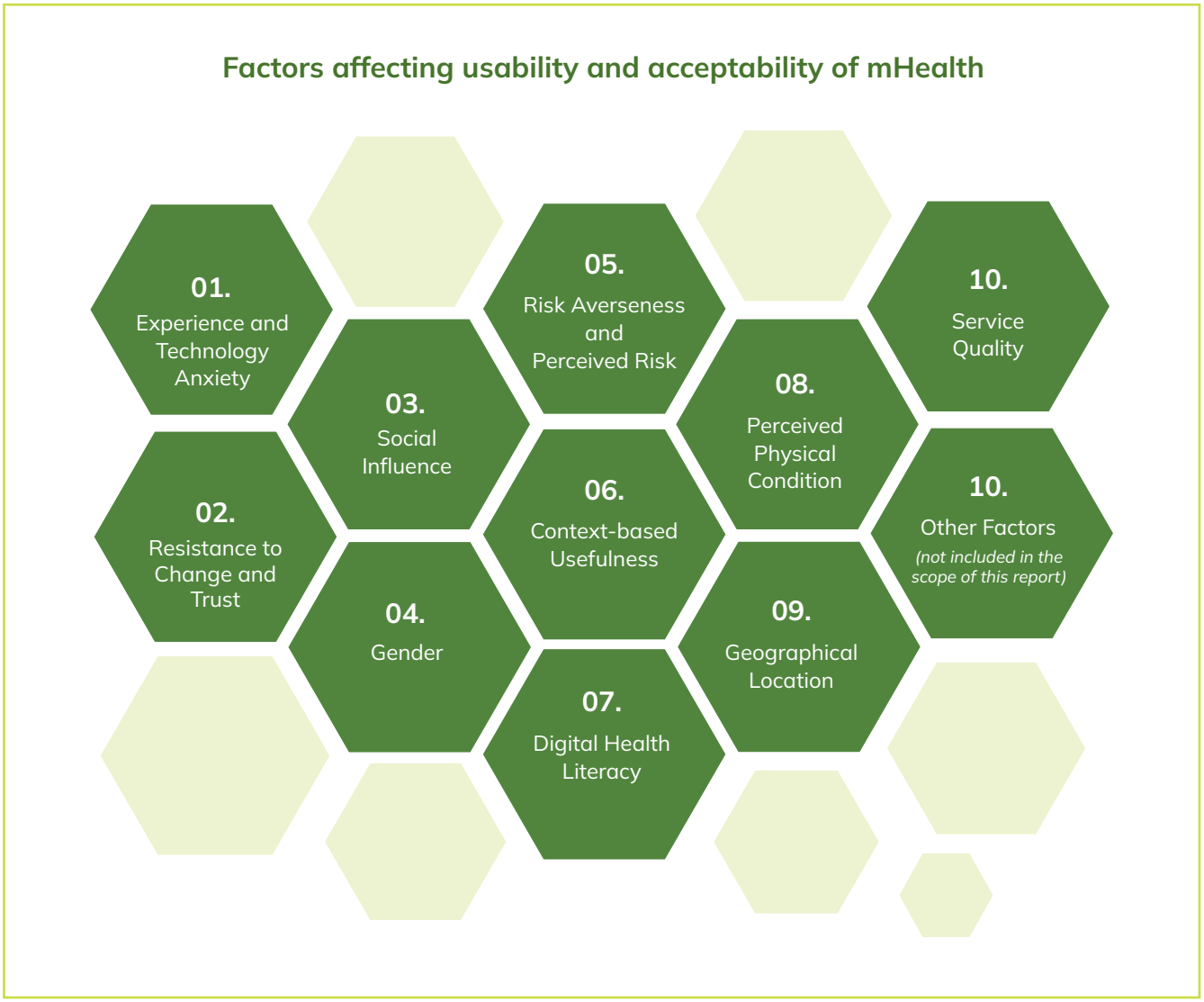


Figure 13: Factors affecting usability and acceptability of mHealth

3.1 Experience and Technology Anxiety

Existing knowledge of a certain technology and the comfort in using it is likely to affect usability and acceptability. Technology Anxiety has been used as a variable in several technology adoption studies to understand the negative emotions a user may experience while using a certain technology. The relationship of such anxiety with PU and PEOU has also been studied extensively among various groups of users.

With respect to mHealth services as a technology, a study showed that the lack of knowledge about mHealth services and fear of leak of private data resulted in reduction in PU and PEOU of users (Shaw and Rajak 2021). Additionally, low digital literacy among the elderly population which implies their lack of experience or existing knowledge in using digital services such as mHealth also relates to experienced technology anxiety. Multiple studies across the world show that non-digital adults and the elderly population are more likely to feel anxiety in using digitally provided services (Ibid.). For example, a study conducted in Italy concluded: *"Based on our data, non-digital adults seemed to experience computer-related anxiety, making them feel technophobic or unconfident regarding digital*

solutions" (Giacomo et al. 2019).

Familiarity with platforms used daily/frequently has also shown to affect the level of comfort and willingness of users to use a new technology. Results from a study conducted in the urban slums of Northern India showed high acceptability (98.3%) among the surveyed population for receiving health-related information through SMS (Faujdar et al. 2022). Another study conducted among a sample of 185 tuberculosis patients in South India showed high acceptability for receiving health reminders via mobile phone. As many as 74.1% of the participants preferred voice calls as the mode for health communication and 76.8% preferred ***"video-based directly observed treatment"*** over ***"in-person directly observed treatment" (***Kumar et al. 2019).

The GSMA Mobile Gender Gap Report provides interesting insights into the confidence of Indian men and women to use a search bar on their own or learn to do something new on their mobile phone. This data gives us interesting insights into the usability of the search function and the likelihood of users trying a new mHealth app. 21% of both Indian men and women mobile users who have never used a search bar before reported that they are confident they could use it on their own. However, out of the ones who had used a search bar before, 98% and 94% of Indian men and women mobile users, respectively, reported being confident of using the search bar on their own (GSM Association 2021).

3.2 Resistance to Change and Trust

One of the triggers for resistance to change are lack of experience and technology anxiety in a population (discussed earlier), affecting a user's behavioural intention to use mHealth services. This resistance may be rooted in their inability to change their ideas, beliefs and habits. In the Indian mHealth context, a study showed that as compared to youngsters, old people are likely to show a higher resistance to change (Shaw and Rajak 2021).

Trust in the benefits of mHealth services, by both users and healthcare personnel, is also important for the successful adoption of the technology. The study by Shaw and Rajak, showed that 'trust' positively affects PU and PEOU in the context of India. As per the data, confidence of the respondents' is increasing and they are becoming convinced of the benefits and varied functionalities of mHealth services (Ibid.). Another study, conducted by the Economist Intelligence Unit (EIU), found that ***"60% of consumers in India predict that within the next three years, mHealth will improve the convenience, cost and quality of their healthcare***" (PwC India, n.d.).

3.3 Social Influence

User decisions for adoption are likely to get shaped by the information and opinions shared by the people around them, affecting both trust and intention. Users in community-based structures are likely to get influenced by family, relatives, friends, etc to adopt or not adopt a new technology. A systematic literature review of mHealth papers done in May 2022, found that 30 papers on ***Sociotechnical Factors Affecting Patients' Adoption of Mobile Health Tools*** addressed social influence as a factor affecting mHealth adoption (Jacob et al. 2022). The adoption by a user may get affected by factors beyond social influence caused only by sharing of opinions by their family and friends. Need for seeking permission and restrictions posed by male members or other family members enjoying a dominant position in the family also affects adoption by certain users in a community. A study on a mHealth pilot intervention in rural Punjab noted that restrictions posed by family members on ownership and use of mobile phone and internet by married women also affected adoption among the female members of the family (Pendse et al. 2022). The same is further discussed in the next section (section 3.4) on gender. Additionally, opinions from caregivers and healthcare professionals also play a key role in the adoption and use of the apps by the patients/users. This influence was particularly effective for people with (and surrounded by those with) less technology experience (Jacob et al. 2022).

3.4 Gender

Growth in numbers of smartphone ownership by women in India has significantly increased from an estimated 14% to 25%, in comparison with smartphone ownership by men which grew from 37% to 41% as per estimates for the years 2019 and 2020 (GSM Association 2021). However, the overall mobile ownership gap and mobile internet user gap between men and women in India remains 15% and 33% respectively, as per the GSMA Consumer Survey, 2020.

An unfortunate picture came to fore in a 2012 survey conducted by Intel and Dalberg where 12% Indian women stated that they believe the internet is not appropriate for them to use and 8% of the women respondents said that their family/friends disapprove of their use of the internet. (Intel and Dalberg 2012). Over the period of 10 years, overall adoption of mobile and internet has improved across the country and granular gender-based data on acceptability and usability of mHealth can help policymakers shape decisions that can encourage the adoption of mHealth apps by users across different genders.

Apart from mobile ownership, internet access and degree of comfort with using different features of mobile phone apps (example, confidence of using search bar function—as discussed earlier), there is a need to assess beliefs around health hazards related to mobile usage, time and degree of access (beyond ownership) to understand factors affecting adoption by users of different genders. Results from a study analysing access and use of a pilot mHealth intervention for postpartum married women of rural Punjab, showed that beliefs about health hazards of mobile devices can especially impact adoption by women in postpartum and pregnancy periods. Further, the study showed that shared access to phones is common among women of a household, as is women's limited access to a phone owned by a male member of the household. At times, the access to phones was limited to using it for calling family members (Pendse et al. 2022).

Apart from mobile ownership, internet access and degree of comfort with using different features of mobile phone apps, there is a need to assess beliefs around health hazards related to mobile usage and degree of access (beyond ownership) to understand factors affecting adoption by users of different genders.

3.5 Risk Averseness and Perceived Risk

The uncertainty of how the user's data will be used and other anticipated negative results associated with using the mHealth services can negatively impact the technology adoption decision by a potential user. The fear of misuse of data and hacking, in particular, is a point of concern for risk averse individuals. Intrinsically linked with resistance to change, Shaw and Rajak's study found that risk-averse users are likely to not want to adopt mHealth applications, as a substitute for their regular medical visits (Shaw and Rajak 2021).

Perceived forms of risk are not restricted to data misuse and loss but extend to the risk of unintended disclosure of health conditions, particularly when a social stigma might be attached to the health issue of the user. A study conducted in South India, among HIV patients receiving antiretroviral treatment support through SMS and IVR based mHealth interventions, found that the patients feared the unintended disclosure of their HIV status to their friends and family who may see the texts or receive the calls if they are away from their phone. Some patients expressed that they preferred to suggest the timings during which they would like to receive such communications. Additionally, few of them actively attempted to conceal the source of such communication (Rodrigues et al. 2015).

3.6 Context-based Usefulness

Usefulness of mHealth services in a user's life may vary widely based on the individual's context. This usability will also vary depending on the nature of service and nature of the application. For example, factors such as mode of language and availability of multilingual services may affect usability of the service for users comfortable with specific languages. Moreover, as discussed in chapter 1, certain mHealth services are targeted towards patients with a certain type of health issue (such as NACO AIDS App, TB Missed Call Initiative, etc) or located in specific areas of the country (such as mHealth services run by state governments or ePharmacies catering to only few serviceable areas) or belonging to a certain user group (such as period tracking app Flo, for menstruating, ovulating and pregnant women). Understandably, these apps would have varying degrees of usability for different groups of users, and have no usability for some.

3.7 Digital Health Literacy

Different levels of literacy (reading and writing), digital literacy, health literacy and digital health literacy influence the usability and acceptability of mHealth.

Low levels of reading and writing literacy often impacts internet usage. A study evaluating mobile internet usage in Sub-Saharan Africa and South Asia found that lack of digital skills and low levels of literacy were among the biggest barriers to using mobile internet. In some regions, reading/writing difficulties were noted as an even bigger barrier to mobile internet usage than lack of digital skills. Of the 19 identified barriers, in India, the study found that 7% of urban and 13% of rural respondents stated reading/writing difficulties as their top barrier to using mobile internet. Among rural respondents, reading/writing difficulties were the most frequently cited barrier in India (GSMA 2022).

Health literacy can be understood as the ability to consume, understand and favourably use health information to prevent illness, promote health and/or treat a medical condition.

In addition to low levels of literacy, mobile internet usage is hampered by lack of digital skills or digital literacy. Digital literacy can be defined as "the ability to use information and communication technologies to find, evaluate, create, and communicate using both cognitive and technical skills" (Atal Innovation Mission, n.d.). The level of digital literacy may vary in a population. For instance, some individuals may have the ability to make phone calls, send SMSs, even use internet-enabled messaging services like WhatsApp, but may not be able to use online banking, shopping or healthcare services. This limits their use of mobile internet. This may be especially true for mHealth services that require consumers to record or upload their health data, download and use their e-prescriptions, order medicines online, make online payments, etc. For mHealth services that require passive usage, for instance health information and education applications/sites where the consumer simply needs to read and understand the information, low levels of digital literacy may suffice. For health information and education services, however, language can become a barrier (discussed in section 1.2.1). Consumers with foundational (basic ability to read and write) or higher levels of literacy in Hindi or Bengali, may not be able to consume health information and education services that are only available in English despite being digitally literate.

Literacy and digital literacy, however, are not enough for using digital healthcare services. Health literacy has a crucial role to play. Health literacy can be understood as the ability to consume, understand and favourably use health information to prevent illness, promote health and/or treat a medical condition. In August 2020, the United States' Centers for Disease Control and Prevention (CDC) defined personal health literacy as "the degree to which individuals have the ability to find, understand, and use information and services to inform health-related decisions and actions for themselves and others" (Centers for Disease Control and Prevention 2022).

For populations with low levels of reading/writing literacy and/or little to no digital literacy and health literacy, achieving 'digital health literacy' can be a significant challenge.

A 2006 paper first conceptualised 'eHealth literacy' as "the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem" (Norman and Skinner 2006). A more recent paper proposed a Transactional Model of eHealth Literacy that defined four eHealth competence levels:

a. "Functional: the ability to successfully read and write about health using technological devices;

b. Communicative: the ability to control, adapt, and collaborate communication about health with others in online social environments;

c. Critical: the ability to evaluate the relevance, trustworthiness, and risks of sharing and receiving health-related information through the digital ecosystem (e.g. the Internet); and

d. Translational: the ability to apply health-related information from the digital ecosystem (e.g. the Internet) in different contexts" (Kessel et al. 2022).

This translational model, however, is beyond the scope of contextualisation for this study. For the purpose of this study, we are relying on digital health literacy, which can be understood as a combination of previously discussed literacies. Individuals who can read and write, have the required digital skills and possess some level of health literacy will also possess some level of digital health literacy required for using mHealth applications/sites. While this does not necessarily mean they will consume mHealth services, individuals with higher levels of digital health literacy are likely to experience better usability and have greater acceptability.

For populations with low levels of reading/writing literacy and/or little to no digital literacy and health literacy, achieving digital health literacy can be a significant challenge. In such cases, assisted eHealth models work better than direct-to-consumer eHealth models. While India's young population is becoming increasingly tech-savvy, there remain populations that would require greater support. A 2022 study analysed telehealth readiness of 150 adults, aged over 60 years, in rural Mysore and Suttur, India (Rasekaba et al. 2022). Of the sample, 62.7% were males and 37.3% were females. 89.3% of the sample had not used the internet for health-related purposes. This group had also not used the internet for banking or shopping services. Only 10.7% had used the internet for shopping and/or banking and/or health-related purposes. When measured for health literacy, the study found that an overwhelming 96.7% were inadequate in terms of reading and 72.7% displayed low confidence when filling forms. 76.7% were not able to understand written information and therefore were inadequate in terms of learning about medical conditions. The study's qualitative analysis provided insight into elderly health behaviour (Ibid.). Health literacy of elderly populations is reliant on and developed through familial and non-familial networks — for instance, someone who has already gone through a medical condition may share information with the elderly person, which may improve the elderly person's ability to understand the medical condition and favourably use the health information being shared with them. For internet-enabled health information or any mHealth services (eg: reminder for physical/offline appointment), elderly respondents who were unable to read and/or did not own mobile phones indicated that they were dependent on family members who were able to read and owned a mobile phone (Ibid.).

3.8 Perceived Physical Condition

Limited in number but some studies assess the perceived physical condition of a user as a factor affecting mHealth adoption by a user in India. Shaw and Rajak's study found that ageing tends to affect "cognitive and physical capabilities such as vision, hearing, and mentality", thus making it difficult for them to use mHealth apps and mobile apps in general (Shaw and Rajak 2021).

3.9 Geographical Location

mHealth studies across the globe have shown mixed results about geographic location of the users being a factor for adoption. Several studies consider lack of network and internet connectivity as a barrier for rural users, however a study by Rush et al states that usefulness of mHealth users in rural areas is high because of the timely delivery of healthcare services and time saved on travelling to far away healthcare facilities (which can now be used in other productive activities) (Rush et al. 2019). Additionally, some studies provide mixed results or dismiss geographical location being a factor in adoption of mHealth altogether (Jacob et al. 2022). Further, based on our discussion with experts, we noted that proximity to physical infrastructure can also affect the usability of mobile health services—particularly for the services that follow an online to offline model (such as online booking of lab tests followed by offline collection of samples—often further followed by online communication of test results and online video/audio consultations).

3.10 Service Quality

Studies conducted with samples from the neighbouring developing country, Bangladesh, have shown that service quality creates a significant positive impact on 'perceived trust' as well as 'service satisfaction', in turn impacting user's intention of continuing the service.

User perception about the excellence of quality of a service or its superiority over available alternates affects adoption decisions. However, as compared to other studied factors, only a limited number of studies have taken into account service quality provided by the mHealth apps as a factor for adoption and usage continuance. With respect to prediction of satisfaction and continuance, Akter et al developed an instrument to measure the "perceived service quality of mHealth" addressing its relation with satisfaction and continuance intention. They have divided service quality into three dimensions, further categorised into 8 sub dimensions (Akter, D'Ambra, and Ray 2013). In another study, Akhter et al developed an mHealth continuance model at the bottom of the pyramid by incorporating the role of service quality and trust. The authors of the study have also done a detailed literature analysis of other research pieces studying the impact of service quality on the mHealth adoption across the world (Akter, D'Ambra, and Ray 2012). Most studies, including the Akter et al studies conducted with samples from the developing country, Bangladesh, have shown that service quality creates a significant positive impact on 'perceived trust' as well as 'service satisfaction', in turn impacting user's intention of continuing the service (Ibid.).

Another study published recently, particularly focusing on adoption of mHealth by the elderly in Bangladesh, used the UTAUT2 model and added 'quality of life' and 'service quality' as factors. In line with the existing literature, this study also found a significant positive impact of service quality on adoption by the users—elderly in this case. However, the second extended variable of 'quality of life' was found to not have a significant impact on mHealth service adoption by the elderly; this was in contradiction with existing studies that reported an impact (Sorwar et al. 2022).[11]

A global survey by the Economist Intelligence Unit studied user drop-out rates across users of different types of mHealth apps:

> *"67% of respondents who have used an mHealth wellness or fitness app with manual data entry discontinued it in the first six months. For automated apps that took information from other devices, the figure was even higher (74%)...61% of patients surveyed by the EIU discontinued using mHealth services that allow better communication with healthcare professionals within the first six months, while 70% stopped using the devices that automatically send data to health providers."*

11 Quality of life has not been studied in detail as a factor however the cited paper discusses research that has studied and elaborated on the same. Refer Sorwar et al. 2022

Conclusion

The **'Telemedicine Practice Guidelines'** released in March 2020 and the progress on the 'Ayushman Bharat Digital Mission' can be seen as acknowledgement by the policymakers to the rapidly digitising healthcare ecosystem of India. This report is an attempt to provide valuable insights on how the mHealth market has evolved over the years and how technology shapes the present and future of access to mHealth in India. Based on the mHealth market mapping and the analysis of technology for access to mHealth, the future of healthcare looks hopeful, provided that markets are allowed to innovate and policies are shaped through evidence, foresight and appropriate inculcation of insights from all stakeholders of the mHealth ecosystem—including the civil society. Technologies such as artificial intelligence are hoped to enhance early diagnosis, wellness and preventive care even further.

The ambitious plan of the National Health Authority to shift from a platform-based ecosystem to a network-based ecosystem is hoped to positively impact availability and usability of mHealth across India. However, affordability and adoption of mHealth, as areas of research, require further in-depth investigation for the context of India.

List of Tables

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Annexure

Annexure 1: List of mHealth Services (Launched in pre-pandemic and pandemic period)

The table below captures the year of launch/year of relevance, download size (on google play store and apple app store), provider/developer, period and category of the 38 mHealth services studied for the pre-pandemic and pandemic era. The categorisation of these apps has been done as explained in **Chapter 1.**

S No	Platform/ Application	Year of Launch/ Year of Relevance	Period	Type of Service	Provider/ Developer	Download Size as on 29th Nov 2022 (on Google Playstore)	Download Size as on 29th Nov 2022 (on App Store)
1	NACO AIDS App	2017	Pre-pandemic	Health education and information	National Health Portal - MOHFW	14 MB	30.1 MB
2	HealthKartPlus*	2013	Pre-pandemic	Health education and information	Bright Lifecare Pvt Ltd	Rebranded	Rebranded
3	Mera Aspataal	2016	Pre-pandemic	Health education and information	National Health Portal - MOHFW	2.9 MB	8.6 MB
4	PMSMA	2016	Pre-pandemic	Health education and information	National Health Portal - MOHFW	4.2 MB	7.8 MB
5	Journey of First 1000 Days	2018	Pre-pandemic	Health education and information	National Health Portal - MOHFW	43 MB	Not available
6	MedWatch	2018	Pre-pandemic	Health education and information	Indian Air Force	65 MB	Not available
7	Poshan HealthPhone	2016	Pre-pandemic	Health education and information	Ministry of Women and Child Development, supported by UNICEF	80 MB	Not available
8	Jeevan Shakti	2019	Pre-pandemic	Health education and information	Dept of Health & Family Welfare, West Bengal	2.6 MB	Not available
9	Vector Borne Disease Control and Surveillance	July 2020 (pandemic app)	Pre-pandemic	Health education and information	Dept of Health & Family Welfare, West Bengal	3.6 MB	Not available
10	eRakt Kosh	2016	Pre-pandemic	Health education and information	National Health Portal - MOHFW	8.3 MB	18.4 MB
11	99DOTS	2014 (pilot); 2016 (launch)	Pre-pandemic	mHealth offline services (SMS/ IVR)	Microsoft Research, National Tuberculosis Elimination Programme	NA	NA
12	mCessation	2016	Pre-pandemic	mHealth offline services (SMS/ IVR)	National Health Portal - MOHFW	NA	NA

S No	Platform/ Application	Year of Launch/ Year of Relevance	Period	Type of Service	Provider/ Developer	Download Size as on 29th Nov 2022 (on Google Playstore)	Download Size as on 29th Nov 2022 (on App Store)
13	102 Call Centre for pregnant women	2015	Pre-pandemic	mHealth offline services (SMS/ IVR)	Dept of Health, Medical and Family Welfare, Govt of Andhra Pradesh	NA	NA
14	Netmeds	2015	Pre-pandemic	ePharmacy	Vitalic Health Pvt. Ltd (Reliance Retail acquired major stake in 2020)	17 MB	193.3 MB
15	TATA 1mg*	2015	Pre-pandemic	ePharmacy	1MG Technologies Pvt. Ltd. (Acquired by Tata Digital Limited in 2021)	14 MB	87.9 MB
16	HealthKart	2011	Pre-pandemic	ePharmacy	Bright Lifecare Pvt. Ltd	22 MB	70.3 MB
17	MedPlus Mart	2015	Pre-pandemic	ePharmacy	MedPlus Health Services Limited	7.2 MB	22.1 MB
18	PharmEasy	2014	Pre-pandemic	ePharmacy	Axelia Solutions Private Limited	19 MB	93.6 MB
19	Jan Aushadhi Sugam	2019	Pre-pandemic	ePharmacy	Pharmaceuticals & Medical Devices Bureau of India	9.8 MB	40.2 MB
20	Practo	2010	Pre-pandemic	eConsultation	Practo Technologies Private Limited	38 MB	146.1 MB
21	TATA Health	2018	Pre-pandemic	eConsultation	Tata Industries Ltd.	NA (discontinued)	NA (discontinued)
22	Apollo 24*7	2013	Pre-pandemic	eConsultation	Apollo Healthco Limited	41 MB	112.3 MB
23	Lybrate	2015	Pre-pandemic	eConsultation	Lybrate, Inc.	17 MB	70.7 MB
24	DocsApp	2015	Pre-pandemic	eConsultation	Docsapp Medical	24 MB	40 MB
25	Pristyn Care	2018	Pre-pandemic	eConsultation	GHV Advanced Care Private Limited	13 MB	51.7 MB
26	MFine	2017	Pre-pandemic	eConsultation	Novocura Tech Health Services Private Limited	45 MB	102.9 MB
27	Manipal Hospitals	2015	Pre-pandemic	eConsultation	Manipal Health Enterprises Pvt Ltd	11 MB	47.3 MB

S No	Platform/ Application	Year of Launch/ Year of Relevance	Period	Type of Service	Provider/ Developer	Download Size as on 29th Nov 2022 (on Google Playstore)	Download Size as on 29th Nov 2022 (on App Store)
28	Fittr	2016	Pre-pandemic	Health data storage and tracking services	Squats	52 MB	223.7 MB
29	Flo	2015	Pre-pandemic	Health data storage and tracking services	Flo Health UK Limited	44 MB	173.1 MB
30	HealthifyMe	2012	Pre-pandemic	Health data storage and tracking services	HealthifyMe Private Limited	65 MB	288.2 MB
31	Google Fit	2014	Pre-pandemic	Health data storage and tracking services	Google LLC	14 MB	272.2 MB
32	My Health Record	2017	Pre-pandemic	Health data storage and tracking services	PrognoCIS™	6.1 MB	Not available
33	NH Care	2020	Pandemic	eConsultation	NarayanaHealth	21 MB	61.6MB
34	Proactive for Her	2021	Pandemic	eConsultation		NA (web browser based only)	NA (web browser based only)
35	Amaha Health	2021 (300% increase in app downloads)	Pandemic	eConsultation	Amaha (MindCrescent Wellness Ventures Inc.)	17 MB	86.2 MB
36	Flipkart Health+	2021	Pandemic	ePharmacy	Microsex HealthBuddy Limted	9.7 MB	501.8 KB
37	Aayu: medicine home delivery	2020 (partnered with Rajasthan Govt)	Pandemic	ePharmacy	MedCords	17 MB	Not available
38	Aarogya Setu	2020	Pandemic	Health data storage and tracking services	NIC	3 MB	13 MB

Note: HealthKartPlus was rebranded as 1mg in 2015 (which was acquired by TATA in 2021), an ePharmacy that provided prescription and over-the-counter drugs.

Annexure 2: Mobile Network Experience Data

Download Speed and Upload Speed Experience: has been measured in Megabits per second (Mbps)

Video Experience: Opensignal reports 'video experience' of users by quantifying the streamed video quality to mobile devices. This is based on the International Telecommunication Union (ITU) approach which includes stall rate, picture quality and loading time as well as the perceived experience of users.

Scale Used for Mapping Video Experience (0 to 100):

Score Interval	Degree	Explanation
>75	Excellent	Very consistent experience across all users, video streaming providers and resolutions tested, with fast loading times and almost non-existent stalling.
65-75	Very Good	Generally fast loading times and only occasional stalling but the experience might have been somewhat inconsistent across users and/or video providers/resolutions.
55-65	Good	An acceptable but inconsistent experience, even from the same video streaming provider and particularly for higher resolutions, with noticeably slow loading times and stalling not being uncommon.
40-55	Fair	Not a good experience either for higher resolution videos (very slow loading times and prolonged stalling) or for some video streaming providers. The experience on lower resolution videos from some providers might have been sufficient though.
<40	Poor	Not a good experience even for lower resolution videos across all providers. Very slow loading times and frequent stalling were common.

Source: Adapted from Opensignal Methodology Overview (Opensignal, n.d.)

In-app Voice Experience:

Opensignal reports 'voice app experience' (stated here as in-app voice experience) of users by quantifying the voice call quality and a few other technical parameters based on an approach devised by International Telecommunication Union (ITU).

Scale Used for Mapping In-App Voice Experience (0 to 100):

Score Interval	Degree	Explanation
>95	Excellent	Operator provides consistently good OTT voice quality experience across the customer base.
87-95	Very Good	Operator generally provides a good OTT voice quality experience. Occasionally, there may be some impairments to the call, primarily related to level of loudness.
80-87	Good	Minor quality impairments experienced by some users. Sometimes the background is not quite clear, it can be either hazy or not loud enough. Clicking sounds or distortion is very occasionally present.
74-80	Acceptable	Perceptible call quality impairments experienced by some users. Short duration of clicking sounds or distortion can be heard, and/or the volume may not be sufficiently loud. Listener is generally able to comprehend without repetition.
66-74	Poor	Call quality impairments experienced by many users. Distortion, clicking sounds or silence experienced during the call, which is perceptible and can be annoying.
60-66	Very Poor	Significant call quality impairments experienced by most users. Occasional instances of distortion, clicking sounds or silence experienced during the call. It can be difficult to understand parts of the conversation without repetition.
45-60	Unintelligible	Frequent instances of long pauses, clicking sounds or distortion can be heard during the call. Frequent repetition is required to be comprehensible, or there are frequent conversation overlaps.
<45	Impossible to communicate	Impossible to communicate.

Source: Adapted from Opensignal Methodology Overview (Opensignal, n.d.)

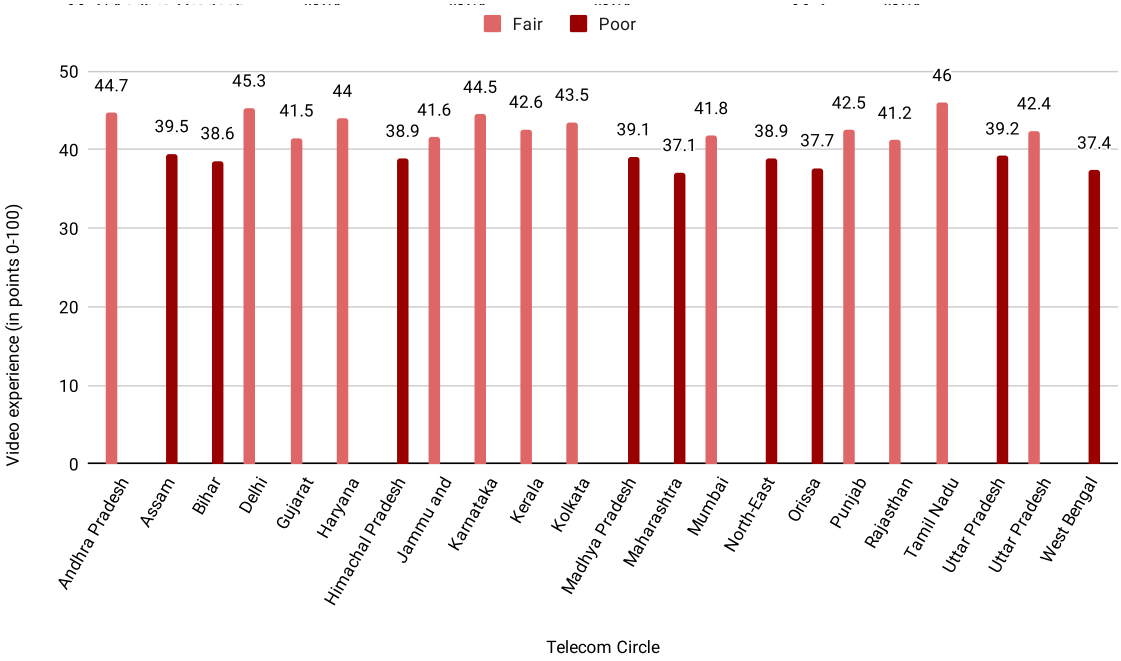
Telecom Service Provider-wise Data on Mobile Network Experience Across 22 Telecom Circles (Jio, Airtel, Vi and BSNL)

Telecom Service Provider: Reliance Jio

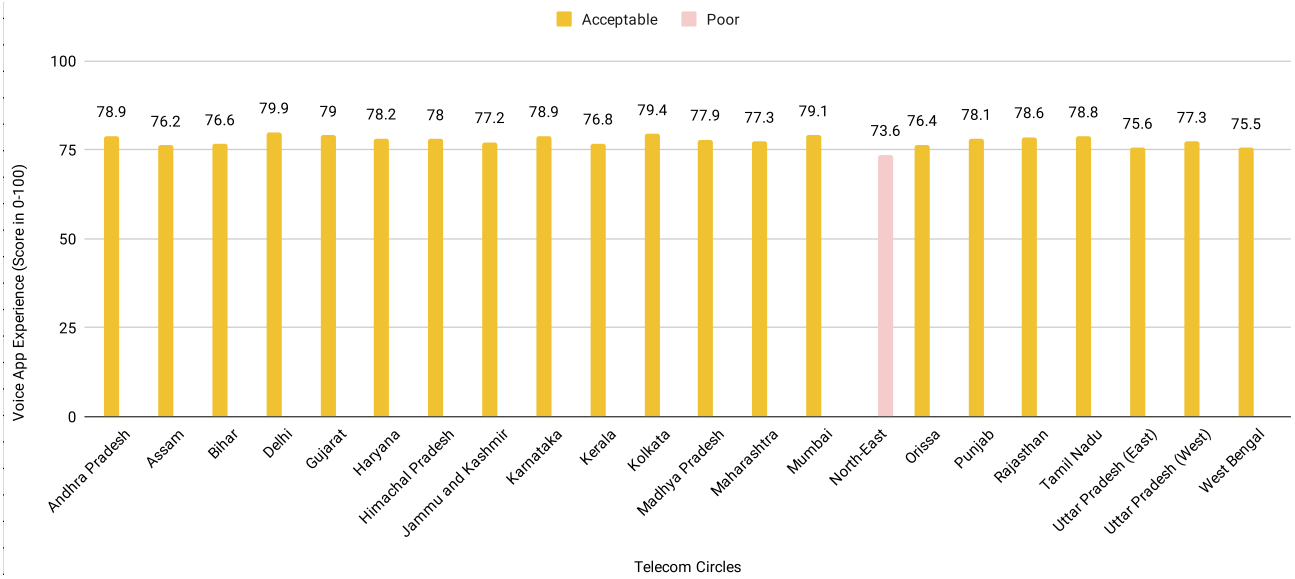
Telecom Circle	Circle Type	Download Speed (in Mbps)	Upload Speed (in Mbps)	Video Experience (out of 100)	In-app Voice Experience (out of 100)	Number of Wireless Subscribers	Wireless subscribers of the TSP as a % of total wireless subscribers
Andhra Pradesh	A	15.3	4	44.7	78.9	28824624	34.62%
Assam	C	12.1	3.5	39.5	76.2	8266401	34.43%
Bihar	C	11.8	3.9	38.6	76.6	33168563	38.63%
Delhi	Metro	13.6	4.8	45.3	79.9	17715367	34.00%
Gujarat	A	12.5	4.6	41.5	79	25753239	38.44%
Haryana	B	14.5	4.4	44	78.2	8544389	31.33%
Himachal Pradesh	C	10.6	4.3	38.9	78	3555618	34.82%
Jammu and Kashmir	C	12.8	3.4	41.6	77.2	4495332	37.96%
Karnataka	A	14.9	4.1	44.5	78.9	19592774	30.19%
Kerala	B	14	3.4	42.6	76.8	9222719	21.12%
Kolkata	Metro	12.9	4.9	43.5	79.4	9748635	40.97%
Madhya Pradesh	B	12.2	3.9	39.1	77.9	35103338	45.87%
Maharashtra	A	10.5	3.7	37.1	77.3	36131701	39.17%
Mumbai	Metro	11.8	4.6	41.8	79.1	11653047	34.05%
North-East	C	11.3	3.1	38.9	73.6	3813016	32.10%
Orissa	C	11.3	3	37.7	76.4	13423905	41.24%
Punjab	B	13	4.2	42.5	78.1	11377338	30.66%
Rajasthan	B	12.7	4.5	41.2	78.6	23431111	37.39%
Tamil Nadu	A	15.3	3.7	46	78.8	23867178	30.00%
Uttar Pradesh (East)	B	11.7	4.2	39.2	75.6	31909847	31.73%
Uttar Pradesh (West)	B	13.4	3.5	42.4	77.3	20773542	32.48%
West Bengal	B	11.1	3.5	37.4	75.5	22361913	39.69%

Source: Adapted from Opensignal data published in April 2022 (measured from 1st December to 28th February 2022) and TRAI data published on 19th April, 2022 (measured for February 2022) (Telecom Regulatory Authority of India 2022)

Video Experience for Jio



In-App Voice Experience - Jio

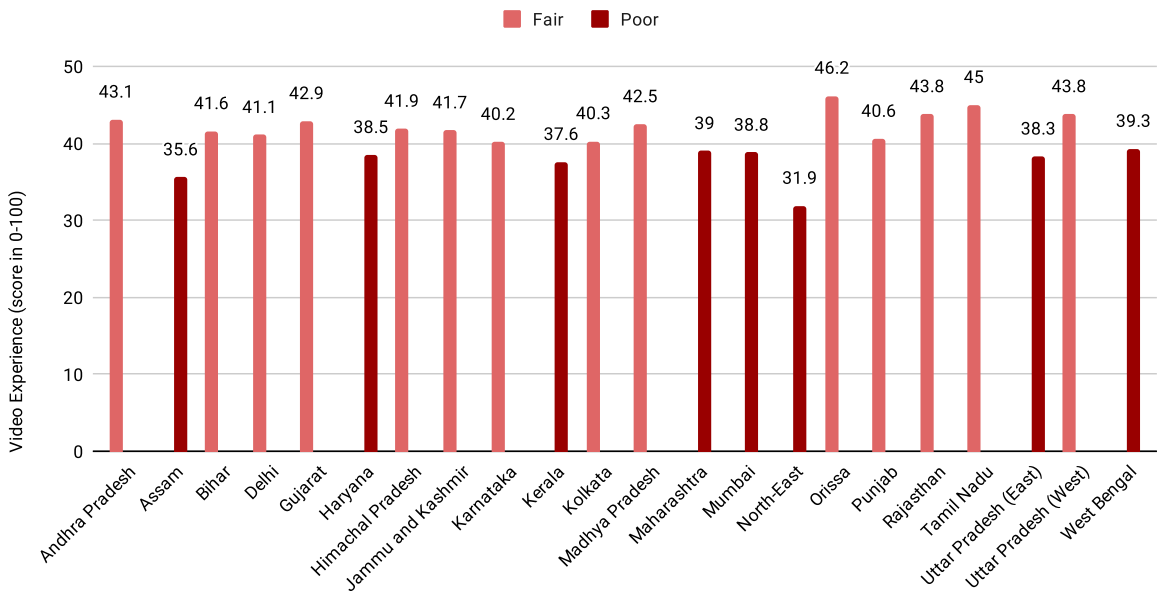


Telecom Service Provider: Airtel

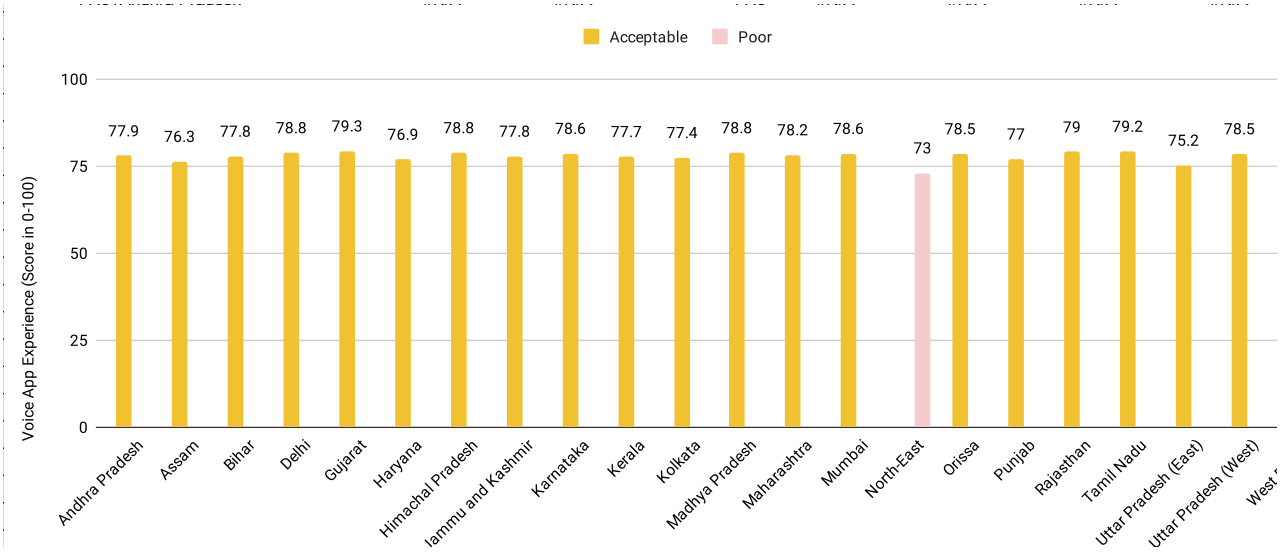
Telecom Circle	Circle Type	Download Speed (in Mbps)	Upload Speed (in Mbps)	Video Experience (out of 100)	In-app Voice Experience (out of 100)	Number of Wireless Subscribers	Wireless subscribers of the TSP as a % of total wireless subscribers
Andhra Pradesh	A	14.6	5.9	43.1	77.9	31321286	37.62%
Assam	C	10.9	2.5	35.6	76.3	9984555	41.59%
Bihar	C	14.9	5.4	41.6	77.8	37096283	43.20%
Delhi	Metro	11.7	2.6	41.1	78.8	16189175	31.07%
Gujarat	A	12.7	4.5	42.9	79.3	11771457	17.57%
Haryana	B	11.4	2.4	38.5	76.9	5860741	21.49%
Himachal Pradesh	C	12.1	4.5	41.9	78.8	3312278	32.43%
Jammu and Kashmir	C	13.5	3.5	41.7	77.8	5588163	47.19%
Karnataka	A	15	4.4	40.2	78.6	30621855	47.18%
Kerala	B	10	2.6	37.6	77.7	7706947	17.65%
Kolkata	Metro	12.9	3	40.3	77.4	5683302	23.89%
Madhya Pradesh	B	12.7	5.1	42.5	78.8	15082785	19.71%
Maharashtra	A	12	4.5	39	78.2	20138484	21.83%
Mumbai	Metro	9.9	3.6	38.8	78.6	9620974	28.11%
North-East	C	9.6	2.3	31.9	73	5589232	47.05%
Orissa	C	16.9	4	46.2	78.5	11004185	33.81%
Punjab	B	12.5	3.6	40.6	77	11798232	31.80%
Rajasthan	B	14.2	5.1	43.8	79	21609275	34.49%
Tamil Nadu	A	13.3	4.5	45	79.2	27585280	34.68%
Uttar Pradesh (East)	B	11.9	3.3	38.3	75.2	36659560	36.45%
Uttar Pradesh (West)	B	14.2	5.5	43.8	78.5	18268262	28.56%
West Bengal	B	13.6	2.8	39.3	76.3	15583324	27.66%

Source: Adapted from Opensignal data published in April 2022 (measured from 1st December to 28th February 2022) and TRAI data published on 19th April, 2022 (measured for February 2022) (Telecom Regulatory Authority of India 2022)

Video Experience - Airtel



In-App Voice Experience - Airtel

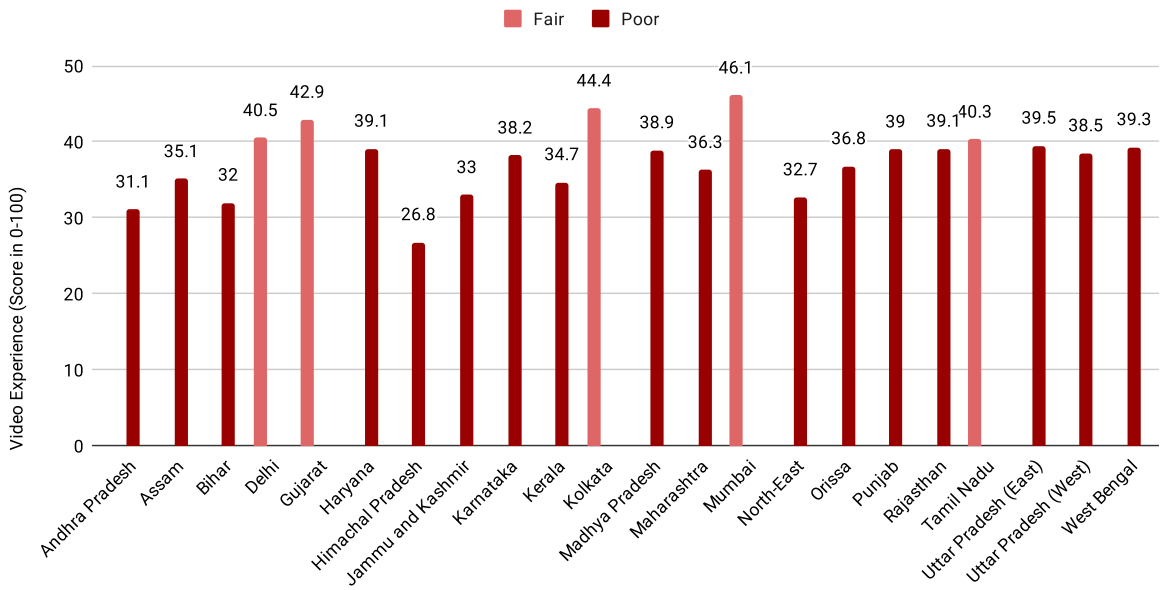


Telecom Service Provider: Vi

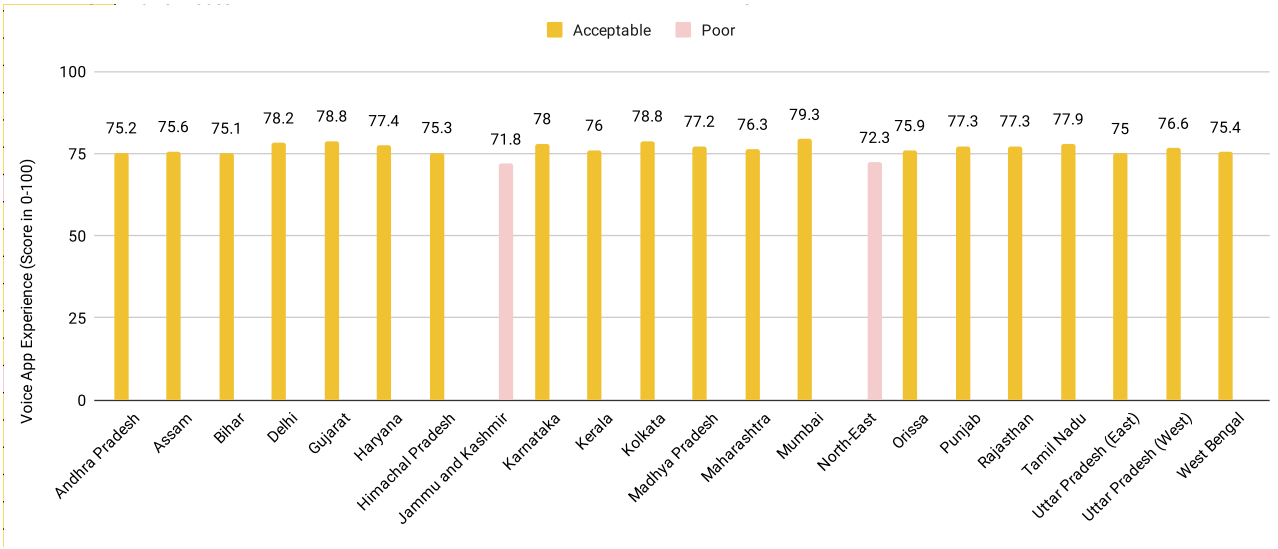
Telecom Circle	Circle Type	Download Speed (in Mbps)	Upload Speed (in Mbps)	Video Experience (out of 100)	In-app Voice Experience (out of 100)	Number of Wireless Subscribers	Wireless subscribers of the TSP as a % of total wireless subscribers
Andhra Pradesh	A	7.6	2.2	31.1	75.2	13803355	16.58%
Assam	C	15.9	6.5	35.1	75.6	2567962	10.70%
Bihar	C	9.8	4.1	32	75.1	10314616	12.01%
Delhi	Metro	12.5	3.3	40.5	78.2	16054137	30.81%
Gujarat	A	14.4	6	42.9	78.8	23867662	35.63%
Haryana	B	12.4	5.7	39.1	77.4	7918102	29.04%
Himachal Pradesh	C	6.4	3.9	26.8	75.3	568575	5.57%
Jammu and Kashmir	C	9.4	4.8	33	71.8	435897	3.68%
Karnataka	A	11.7	6.1	38.2	78	7827250	12.06%
Kerala	B	12	3.2	34.7	76	16163782	37.02%
Kolkata	Metro	16.4	5	44.4	78.8	6136945	25.79%
Madhya Pradesh	B	15.4	4.6	38.9	77.2	20307524	26.54%
Maharashtra	A	12.7	4	36.3	76.3	29301925	31.77%
Mumbai	Metro	14.1	5.6	46.1	79.3	11846621	34.62%
North-East	C	12.5	6.4	32.7	72.3	1120579	9.43%
Orissa	C	13.7	4.8	36.8	75.9	1883692	5.79%
Punjab	B	12.4	6.1	39	77.3	8618570	23.23%
Rajasthan	B	12.2	4.9	39.1	77.3	11183574	17.85%
Tamil Nadu	A	13.1	5.8	40.3	77.9	17898703	22.50%
Uttar Pradesh (East)	B	16.5	4.9	39.5	75	20942068	20.82%
Uttar Pradesh (West)	B	15.8	5.8	38.5	76.6	19026856	29.75%
West Bengal	B	16.4	5	39.3	75.4	15804656	28.05%

Source: Adapted from Opensignal data published in April 2022 (measured from 1st December to 28th February 2022) and TRAI data published on 19th April, 2022 (measured for February 2022) (Telecom Regulatory Authority of India 2022)

Video Experience - Vi



In-App Voice Experience - Vi



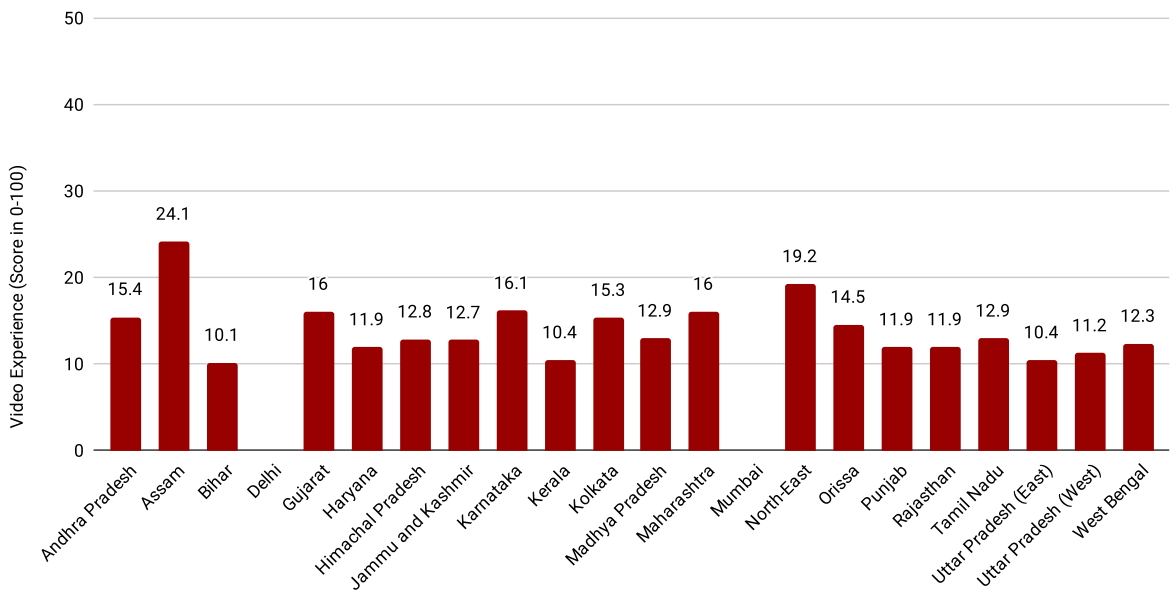
Telecom Service Provider: BSNL

Telecom Circle	Circle Type	Download Speed (in Mbps)	Upload Speed (in Mbps)	Video Experience (out of 100)	In-app Voice Experience (out of 100)	Number of Wireless Subscribers	Wireless subscribers of the TSP as a % of total wireless subscribers
Andhra Pradesh	A	3	1	15.4	65.2	9307279	11.18%
Assam	C	5.3	1.8	24.1	69.2	3188296	13.28%
Bihar	C	2	0.8	10.1	63.4	5291655	6.16%
Delhi*	Metro	NA	NA	NA	NA	NA	NA
Gujarat	A	3.3	1.3	16	68.9	5596715	8.35%
Haryana	B	2.4	1.1	11.9	67.6	4946357	18.14%
Himachal Pradesh	C	2.5	0.9	12.8	67.7	2776272	27.18%
Jammu and Kashmir	C	2.9	0.7	12.7	62.4	1322743	11.17%
Karnataka	A	2.9	0.9	16.1	67.3	6859823	10.57%
Kerala	B	1.9	0.9	10.4	64.2	10567195	24.20%
Kolkata	Metro	2.8	1	15.3	67.5	2223499	9.35%
Madhya Pradesh	B	2.6	1	12.9	67.8	6029470	7.88%
Maharashtra	A	3.1	1.3	16	68.1	6665130	7.23%
Mumbai*	Metro	NA	NA	NA	NA	NA	NA
North-East	C	3.3	1.4	19.2	66.3	1356526	11.42%
Orissa	C	2.7	1	14.5	66.1	6234994	19.16%
Punjab	B	2.4	0.8	11.9	67	5308297	14.31%
Rajasthan	B	2.4	0.8	11.9	66.3	6436509	10.27%
Tamil Nadu	A	2.7	0.9	12.9	65.5	10142269	12.75%
Uttar Pradesh (East)	B	2.3	0.8	10.4	65	11070126	11.01%
Uttar Pradesh (West)	B	2.4	0.8	11.2	65.4	5895131	9.22%
West Bengal	B	2.5	0.9	12.3	62	2597378	4.61%

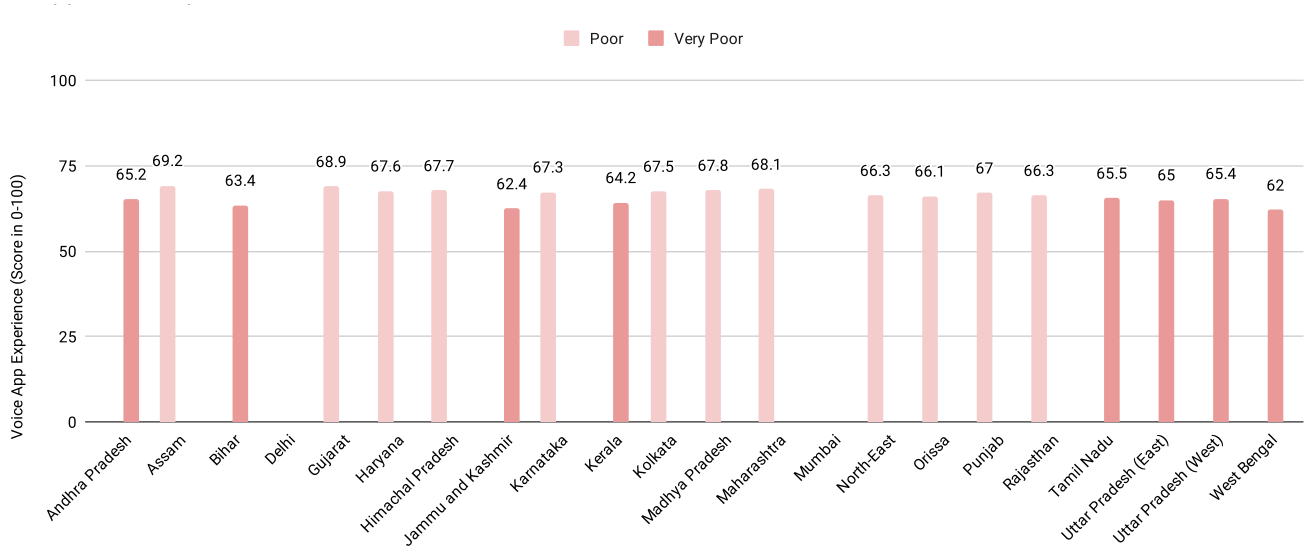
*BSNL does not operate in Mumbai and Delhi telecom circles. Government provider MTNL provides its services in these two circles instead.

Source: Adapted from Opensignal data published in April 2022 (measured from 1st December to 28th February 2022) and TRAI data published on 19th April, 2022 (measured for February 2022) (Telecom Regulatory Authority of India 2022)

Video Experience - BSNL



In-App Voice Experience - BSNL



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