Artificial Intelligence in the Healthcare Industry in India

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Executive Summary

The use of AI in healthcare in India is increasing with new startups and large ICT companies offering AI solutions for healthcare challenges in the country. Such challenges and solutions include addressing the uneven ratio of skilled doctors to patients and making doctors more efficient at their jobs; the delivery of personalized healthcare and high quality healthcare to rural areas; and training doctors and nurses in complex procedures.[1] Companies are offering a range of solutions including automation of medical diagnosis, automated analysis of medical tests, detection and screening of diseases, wearable sensor based medical devices and monitoring equipment, patient management systems, predictive healthcare diagnosis and disease prevention.[2] In developing these solutions, a commonly cited challenge has been the lack of comprehensive, representative, interoperable, and clean data — something that is intended to be addressed through the Electronic Health Records Standards developed by the Ministry of Health and Family Welfare in 2016.[3] Other challenges include access to open medical data sets and adoption by practitioners.[4]

This report seeks to map the present state of AI in the healthcare sector in India. In doing so, it explores: ***Use***: What is the present use of AI in healthcare? What is the narrative and discourse around AI and healthcare in India? ***Actors***: Who are the key stakeholders involved in the development, implementation and regulation of AI in the healthcare industry? ***Impact***: What is the potential and existing impact of AI in healthcare? ***Regulation***: What are the challenges faced in policy making around AI in the healthcare industry?

Methodology

This report explores the state of AI in the healthcare industry in India. From CIS' literature review undertaken in December 2017, we learned that there is no single definition of AI.[5] For the purposes of this report, we have drawn upon the definitions outlined in the literature review and reached a broad understanding of AI as a dynamic learning system that can be used in decision making and actioning.

To do this, the AI ecosystem in the industry was mapped by identifying AI solutions, practitioners, researchers, funders, government, and conferences/exhibitions. For the mapping, the research draws upon news items, company websites, academic articles, industry reports, interviews, and roundtable inputs to identify different AI solutions being used in each sub-segment of the healthcare industry in India. Search terms used when searching for AI solutions in health include — artificial intelligence, machine learning, neural networks, multi-agent systems, innovation in healthcare and fuzzy logic. Search terms used for health include — health, healthcare, diagnostics, hospitals, telemedicine, pharmaceuticals, medical equipment and supplies, and health insurance, clinical data. The findings in the report and the mind map represent what we have been able to find untill the date of publishing and is not necessarily comprehensive.

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1 How innovations in AI, virtual reality are advancing healthcare in India to new frontiers, J Vignes. Retrieved January 5, 2018, from **http://economictimes.indiatimes.com/articleshow/59060040.cms**

2 Artificial Intelligence Based Healthcare Startups in India, Tiash Saha. Retrieved January 5, 2018, from **https://news.medgenera.com/12-artificial-intelligence-healthcare-startups-india-ai/**

3 Notification on Electronic Health Standards, 2016. Retrieved January 5, 2018, from **http://mohfw.nic.in/sites/default/files/17739294021483341357_1.pdf**

4 Future of Artificial Intelligence in Healthcare in India, Economic Times Healthworld. Retrieved January 5, 2018, from **http://health.economictimes.indiatimes.com/news/industry/future-of-artificial-intelligence-in-healthcare-in-india/56174804**

5 Artificial Intelligence: Literature Review (2017, December 16). Retrieved January 5, 2018, from **https://cis-india.org/internet-governance/blog/artificial-intelligence-literature-review**

To broadly understand the function of AI in healthcare, the research categorized the healthcare industry into segments based on the categorization found in the 2017 IBEF report on healthcare market in India.[6] The research adopts three broad functions derived from an interview, that AI is being used for in the healthcare industry: prescriptive, descriptive, and predictive.[7] To give clarity on the state of AI in the industry, each identified solution in each segment was categorized into one of these three functions.

The policy and legal components of the report highlights existing policy, case law, and standards that have implications for the use of AI. The research brings in examples from two different contexts, US and UK, to understand how the regulatory framework around AI in health is evolving and how the Indian regime compares.

The challenges to the use of AI in healthcare were identified predominantly through a review of literature, interviews and roundtable inputs.

Introduction

The emerging use cases of Artificial Intelligence (AI) in the healthcare sector can be seen as a collection of technologies enabling machines to sense, comprehend, act and learn so they can perform administrative and clinical healthcare functions, as well as be used in research and for training purposes.[8]

Unlike legacy technologies that only complemented human skills, health AI today can significantly expand the scope of human activity. These technologies[9] include, among others, natural language processing, intelligent agents, computer vision, machine learning, expert systems, chatbots and voice recognition.[10] These technologies can also potentially be used to compensate for a physician's cognitive biases (such as "recency bias," where one is more likely to allow the last case one treated to inform the course of treatment for the next patient.)[11]

This use and adoption of AI can be seen at varying levels across the healthcare ecosystem. Machine learning can be used to address the issue of reporting in siloed Electronic Health Records (EHRs) and instead redirect these reports toward analysis and predictive modelling.[12] This technology can also be applied to preventative health programs. Machine learning can be used to merge an individual's –omic (genome, proteome, metabolome, microbiome) data with other data sources such EHRs to predict the likelihood of developing a disease, which can then be addressed through timely interventions such as preventative therapy.[13]

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6 Advantage India Healthcare Report, IBEF. Retrieved January 5, 2018, from **https://www.ibef.org/download/Healthcare-November-2017.pdf**

7 Dr. Agrawal, A. (2017, November 24). Personal Interview

8 Ma Si (2017, April 20), New partnership to leverage AI technology in medical fields, Retrieved January 5, 2018, from **http://www.chinadaily.com.cn/business/tech/2017-04/20/content_29013915.htm**.

9 Artificial Intelligence: Literature Review (2017, December 16). Retrieved January 5, 2018, from **https://cis-india.org/internet-governance/blog/artificial-intelligence-literature-review**

10 A. Ericson, (2017, October 31), Health AI Mythbusters: Separating Fact from Fiction, Retrieved January 5, 2018, from **https://www.accenture.com/us-en/blogs/blogs-health-ai-mythbusters-separating-fact-fiction**.

11 K. Safavi, (2016, December 15), The AI Will See You Now, Retrieved January 5, 2018, from **https://www.accenture.com/us-en/blogs/blogs-intelligence-transform-healthcare**.

12 **https://healthitanalytics.com/news/can-artificial-intelligence-relieve-electronic-health-record-burnout**

13 R. Eubanks, (2017, October 3), Artificial Intelligence and the Healthcare Ecosystem – Part One, Retrieved January 5, 2018, from **https://www.capgemini.com/2017/10/artificial-intelligence-and-the-healthcare-ecosystem-part-one/**.

AI addresses the issue of information overload often faced in healthcare by employing machine learning to make sense of otherwise overwhelming volumes of healthcare data, which can otherwise threaten the adoption of evidence-based practice. This phenomenon is known as "filter failure", where the main problem is not too much information, but how such information is analysed. This is exemplified by inadequate information retrieval systems for point-of-care settings, difficulty identifying all relevant evidence in an exceedingly diverse landscape of information resources, and lack of basic health information literacy.[14] Programs such as IBM's Watson for Oncology[15] extensively evaluate medical literature to prescribe the best course of treatment. Researchers have used smart algorithms to extract information from radiology reports contained in a repository spanning multiple institutions. They report that their approach "provides an effective automatic method to annotate and extract clinically significant information from a large collection of free-text radiology reports"; that it could be used to help clinicians better understand these radiology reports and prioritize their review process; that it could link radiology reports to information from other data sources such as electronic health records and the patient's genome, and that "extracted information also can facilitate disease surveillance, real-time clinical decision support for the radiologist, and content-based image retrieval."[16]

AI can also prevent recidivism/relapse by helping follow up on cases and making further recommendations. EHRs combined with AI can be used to predict how a patient's genetic makeup may affect illness or react to a certain medication. Theoretically, AI can use a person's genome to recommend the most effective treatment option with the least side effects.[17]

Use of AI in Healthcare

The use of AI in the healthcare industry is diverse across sub-sectors. To understand the type of 'AI' that different solutions are being developed around, the uses of AI in healthcare can be categorized into the following broad categories as[18]:

Descriptive

Descriptive AI is the most widely used in healthcare technology today, and holds the most promise in terms of short-term potential[19]. It quantifies events that have already occurred and uses this data to gain further insights, such as detecting trends and minor changes that may otherwise escape detection by medical professionals.

For instance, such technology can be used to identify patterns in fracture detections and skin lesions. Additionally, these technologies have been shown to outperform humans in detecting subtle wrist fractures.[20]

14 Klerings I, Weinhandl AS, Thaler KJ (2015, July 27), Information overload in healthcare: too much of a good thing?, Retrieved January 5, 2018, from **https://www.ncbi.nlm.nih.gov/pubmed/26354128**.

15 IBM Watson for Oncology. Retrieved January 05, 2018, from **https://www.ibm.com/in-en/marketplace/ibm-watson-for-oncology**.

16 Hassanpour, S., & Langlotz, C. P. (2016). Information extraction from multi-institutional radiology reports. *Artificial intelligence in medicine*, 66, 29-39. Abstract Retrieved January 5, 2018, from **https://www.ncbi.nlm.nih.gov/pubmed/26481140**.

17 P. Perry, How Artificial Intelligence will Revolutionize Healthcare, Retrieved January 5, 2018, from **http://bigthink.com/philip-perry/how-artificial-intelligence-will-revolutionize-healthcare**

18 Dr. Agrawal, A. (2017, November 24). Personal Interview.

19 Dr. Agrawal, A. (2017, November 24). Personal Interview.

20 Dr. Agrawal, A. (2017, November 24). Personal Interview.

Predictive

Predictive AI uses descriptive data to attempt to make predictions about the future. AI is used by medical professionals to provide insights and suggest actions in a predictive manner.[21] AI can play a significant role in predictive healthcare technologies and hospital management. Some illustrative cases which would improve efficiencies and curtail costs are[22]:

1. By minimising drudgery and enhancing productivity of doctors by prioritising patients based on criticality. Predictive AI can be used in triage, which is the process of determining the priority of patients' treatments based on the severity of their condition.

2. Through decentralisation of diagnostic testing and expediting disease screening

3. By training modules on larger data sets, which can then detect and identify positive cases early, and have proven to be more effective at disease identification

4. By analysing heart rates similar to ECG and predicting heart attacks

5. By increasing efficiencies such as patient admission and discharge time

6. By strengthening and customising Health Management Information Systems to give real time reports

7. Through healthcare data analytics for administrative process improvements

Predictive AI can perform the functions of a clinician, possibly substituting for human labour. Large parts of India presently face a shortage of primary care clinicians. Healthcare programs are limited by the lack of availability of clinicians and limited capacity. AI can help fill this gap. Artelus[23] seeks to use AI to help in primary screening in rural areas that are understaffed. Apps such as Wysa[24] are able to monitor and predict mental health issues. This technology can also be high touch (where each patient is given personal attention[25]). There is no possibility of communicating unintended non-verbal cues such as judgment, and no sense of the usual hierarchy often found in clinician-patient relationships. As a result, patients are more likely to be honest with virtual humans and more compliant with their coaching and care plans.[26]

Prescriptive

Prescriptive AI furthers the purpose of predictive AI, and not only detects trends that may not be predicted by humans, but also suggests possible treatments based on nuances in the diagnosis. This decision-making ability makes prescriptive AI the most interesting and the most controversial use case in the near term.[27]

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21 Dr. Agrawal, A. (2017, November 24). Personal Interview.

22 Mathur, V. and ors. (2017, September), *Billionfit: Technology redesigning healthcare* [White paper]. Retrieved January 5, 2018, from Grant Thornton India LLP: **http://www.grantthornton.in/globalassets/1.-member-firms/india/assets/pdfs/billionfit-technology--redesigning-healthcare.pdf**.

23 Artificial Learning Systems., Retrieved January 5, 2018, from **http://artelus.com/products.php**.

24 Wysa - AI coach for behavioural health., Retrieved January 5, 2018, from **https://www.wysa.io/**.

25 **http://www.oncnursingnews.com/publications/oncology-nurse/2016/june-2016/hightech-hightouch-care**

26 F. Dare (2017, May 3), Can High Tech Be High Touch In Healthcare?, Retrieved January 5, 2018, from **https://www.accenture.com/us-en/blogs/blogs-high-tech-high-touch-healthcare**.

27 Dr. Agrawal, A. (2017, November 24). Personal Interview.

Prescriptive AI can potentially be mobilised as a cognitive agent that mimics the brain to reduce cognitive load on humans. Healthcare is one of the most knowledge-intensive of all industries. AI-powered smart agents can search, find, present and apply the most current clinical knowledge in partnership with physicians, nurses, and researchers, significantly improving clinician efficiency and capacity, and quality of care.[28]

State of AI in the Indian Healthcare Industry

There are reports to suggest that AI could potentially add USD 957 billion (or 15% of current gross value added) to the Indian economy by 2035[29] and investment in AI in the Indian healthcare industry appears to be growing. For example, of the USD 5.5 billion raised by global digital healthcare companies In the July-September 2017 quarter, at least 16 Indian healthcare IT companies received funding.[30] State governments are also providing support to AI startups - with reports quoting the Karnataka government mobilising 2,000 crore by 2020 towards supporting the same. The Karnataka government also has a Startup Policy and Karnataka Information Technology Venture Capital Fund that can support AI startups.[31] The integration of AI in healthcare in India has been seen as a key technology towards improving the efficiency, quality, cost, and reach of healthcare and is being promoted by stakeholders like FICCI[32], and the Office of the Prime Minister[33]. In India, assistive AI enjoys the most potential for growth while technologies that have the potential to replace doctors have the least chances of succeeding, one of the reasons being conflict of interest among the medical establishment.[34] From a review of AI and health solutions, reports, and news items in India, the focus of most AI-based healthcare initiatives in India has been to extend medical services to traditionally underserved populations in India such as rural areas that do not have the required infrastructure or enough primary physicians, and economically weaker sections of society who may not be able to afford certain medical facilities. Therefore, AI as it is used in healthcare in India appears to be addressing issues of economic disparity rather than widening existing gaps as feared.[35] A review of companies involved in AI and healthcare in India also shows that foreign companies are developing and testing new solutions in India.

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28 F. Dare (2017, May 3), Can High Tech Be High Touch In Healthcare?, Retrieved January 5, 2018, from **https://www.accenture.com/us-en/blogs/blogs-high-tech-high-touch-healthcare**.

29 Accelerating India's Economic Growth With Artificial Intelligence, Accenture (2017), Retrieved January 5, 2018, from **https://www.accenture.com/t20171220T030619Z__w__/in-en/_acnmedia/PDF-68/Accenture-ReWire-For-Growth-POV-19-12-Final.pdf**

30 These include CureFit, a healthcare and fitness app maker, which raised USD 25 million from Accel Partners, Kalaari Capital, IDG Ventures, and the UC-RNT Fund. It also secured around USD 341,531 in funding from Trifecta Capital and Pratithi Investment Trust. 1mg (previously HealthKartPlus) raised USD 15 million from HBM Healthcare Investments, Maverick Capital Ventures, Sequoia India, Omidyar Network and Kae Capital and online doctor consultation platform Mfine raised USD 1.5 million from Stellaris Venture Partners and healthcare entrepreneurs Mayur Abhaya and Rohit M A. Retrieved January 5, 2018, from **https://economictimes.indiatimes.com/tech/ites/healthcare-it-companies-raise-5-5-billion-in-vc-funding-in-jan-sep-2017/articleshow/61182157.cms**

31 V. Pitchiah, Karnataka Govt to Invest $6 Mn in AI, Data Science Hub (2017, October 3). Retrieved January 5, 2018, from **https://www.vccircle.com/karnataka-govt-to-invest-6-1-mn-in-ai-data-science-hub/**

32 Re-engineering Indian health care (September 2016), Retrieved January 5, 2018, from **http://www.ey.com/Publication/vwLUAssets/ey-re-engineering-indian-health-care/$FILE/ey-re-engineering-indian-health-care.pdf**

33 S. Rao. (2017, July 7), Bengaluru, Israeli firms join hands to deploy artificial intelligence, Retrieved January 5, 2018, from **https://timesofindia.indiatimes.com/city/bengaluru/bengaluru-israeli-firms-join-hands-to-deploy-artificial-intelligence/articleshow/59485190.cms**

34 Dr. Agrawal, A. (2017, November 24). Personal Interview.

35 A. Roy, (2017, July 10), How IoT and AI is changing the face of rural healthcare, Retrieved January 5, 2018, from **https://tech.economictimes.indiatimes.com/news/technology/how-iot-and-ai-is-changing-the-face-of-rural-healthcare/59525303**

As suggested by the results of a TCS global survey,[36] healthcare companies expect cognitive tools to have a moderate and polar impact on employment levels at their companies in 2016, with bigger changes ahead. On one hand, respondents to the survey expected AI to reduce jobs going forward while on the other hand, respondents envisioned the creation of new jobs from AI projects. A report by Accenture predicts that clinical health AI applications can result in USD 150 billion in annual savings in the US and that the market is expected to grow to USD 6.6 billion by 2021.[37]

Emerging markets such as India also face a skills gap. Tools that are AI-enabled can potentially help less-skilled people make difficult decisions. Consulting highly skilled doctors can be left for cases where the AI tool concludes that the confidence in a decision is low, which allows the expert to devote his time only to important cases.[38] Examples of these include mental health assistant applications such as Wysa, which is a chatbot that allows certain cases to be escalated to a human assistant depending on need. In these markets, AI also tackles issues of accessibility and affordability by helping unaddressed demographics access low-cost healthcare.[39] Additionally, since India is rich in data, it is also an important testing ground for new artificial intelligence solutions.

AI and Healthcare Segments in India

The healthcare industry in India is made up of a number of segments.[40] Through a review of companies developing AI solutions for health, health practitioners using AI, and researchers looking into the potential of AI and health, it was found that AI is employed in a variety of ways across the different segments including:

1. Hospitals: These include government hospitals, including healthcare centres, district hospitals and general hospitals; and private hospitals, which include nursing homes and mid-tier and top-tier private hospitals. From a review of solutions adopted it appears that hospitals in India are employing descriptive and predictive AI.

For instance, the Manipal Group of Hospitals has tied up with IBM's Watson for Oncology to aid doctors in the diagnosis and treatment of 7 types of cancer. Watson for Oncology is used across its facilities, where more than 2.00,000 patients receive cancer care each year[41]. Here, AI is used to analyse data and research evidence and improve the quality of the report, in turn increasing patient trust. Importantly, patients are fully aware of the process and provide their express consent. Due care is also taken to preserve patient anonymity. However, at the global level, Watson has recently come under fire from physicians across the world for allegedly posing as "a 'mechanical turk' - a human-driven engine masquerading as an artificial intelligence." It was reported that instead of using AI, it actually works by convening a small panel of cancer experts, who formulate recommendations for specific patient

36 TCS (2017). Getting Smarter by the Sector: How 13 Global Industries Use Artificial Intelligence. Retrieved January 5, 2018, from **http://sites.tcs.com/artificial-intelligence/#**

37 Artificial Intelligence: Healthcare's New Nervous System. Retrieved January 5, 2018, from **https://www.accenture.com/us-en/insight-artificial-intelligence-healthcare**

38 J. Vignesh (2017, June 9), How innovations in AI, virtual reality are advancing healthcare in India to new frontiers, Retrieved January 5, 2018, from **https://economictimes.indiatimes.com/small-biz/startups/how-innovations-in-ai-virtual-reality-are-advancing-healthcare-in-india-to-new-frontiers/articleshow/59060040.cms**.

39 N. Bareja (2016, August 18), Impact of Novel Technology on Low Cost Healthcare in India, Retrieved January 5, 2018, from **https://sigtuple.com/blog/low-cost-healthcare-in-india/**

40 IBEF Healthcare (2017, November), Retrieved January 5, 2018, from **https://www.ibef.org/download/Healthcare-November-2017.pdf**

41 Manipal Hospitals, Watson for Oncology Report (2016, September 7), Retrieved January 5, 2018, from **https://watsononcology.manipalhospitals.com/Manipal-Hospitals-Watson-Sample-Report.pdf**

profiles - “These recommendations represent the best guesses of these experts, supported by medical literature and personal experience. IBM has never allowed an independent study of Watson for Oncology. No follow up is done to evaluate whether its recommendations help patients.”[42] Foreign physicians have also complained that the population that Watson is trained on does not accurately reflect the diversity of cancer patients across the world, and as a result, it is heavily biased towards American patients and standards of care.[43]

Aravind Eye Care Systems is presently working with Google Brain, after previously helping Google develop its retinal screening system by contributing images to train its image parsing algorithms. After successful clinical trials to detect signs of diabetes-related eye disease, it is now attempting to put it to routine use with patients.[44]

Products such as Microsoft Azure, Machine Learning, Data Analytics, CRM online and Office 365 are being used by private healthcare providers such as Fortis Healthcare, Apollo Hospitals, L V Prasad Eye Institute (LVPEI), Narayana Health and Max Healthcare to improve patient care.[45]

2. Pharmaceuticals: These include manufacturing, extraction, processing, purification and packaging of chemical materials for use as medications for humans or animals. From a review of solutions adopted it appears that pharmaceuticals in India are employing descriptive and predictive AI with prototypes for prescriptive AI being developed and tested.

The most common use of AI in pharmaceuticals is in drug discovery, where AI is mobilised to scan through all available literature on a particular molecule for a drug (eg. targeted molecule discovery), which would otherwise be impossible for even a group of people to manually carry out.[46]

In addition to streamlining the process of drug discovery[47], the application of AI in pharma offers additional advantages such as identification of both tangible and intangible enhanced value proposition, enhanced competitor differentiation, optimal resource allocation for maximum market share gain, revenue and profit, ability to maximize growth, customizing sales and marketing messaging for greater customer engagement, and automation of sales and marketing messages and channels.[48] Abbott Healthcare has used India as a testing ground for new tech innovations such as apps for the heart and liver, as well as vertigo

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42 Watson for Oncology isn't an AI that fights cancer, it's an unproven mechanical turk that represents the guesses of a small group of doctors. (2017, November 13). Retrieved January 5, 2018, from **https://boingboing.net/2017/11/13/little-man-behind-the-curtain.html**

43 C. Ross, I. Swetlits, IBM pitched its Watson supercomputer as a revolution in cancer care. It’s nowhere close (2017, September 5). Retrieved January 5, 2018, from **https://www.statnews.com/2017/09/05/watson-ibm-cancer/**

44 T. Simonite, (2017, June 7), Google’s Ai Eye Doctor Gets Ready To Go To Work In India,Retrieved January 5, 2018, from **https://www.wired.com/2017/06/googles-ai-eye-doctor-gets-ready-go-work-india/**

45 S. Jaiswal, (2016, September 23), Healthcare & BFSI companies lead Microsoft local cloud adoption, Retrieved January 5, 2018, from **https://news.microsoft.com/en-in/healthcare-bfsi-companies-lead-microsoft-local-cloud-adoption/**

46 Rangasai, A. (2017, December 15). Personal Interview.

47 Reuters (2017, July 2), Pharma turns to AI to speed drug discovery, Retrieved January 5, 2018, from **http://www.thehindu.com/business/Industry/pharma-turns-to-ai-to-speed-drug-discovery/article19198759.ece**

48 Advanced Analytics for Pharma Marketing Efficiency and Growth, Retrieved January 5, 2018, from **http://www.eularis.com/en-gb/services**

exercises (which use augmented and virtual reality).[49] Pharmarack[50] is a software-as-a-service (SaaS) based application that utilises AI to automate the pharmaceutical supply chain management.

3. Diagnostics: These comprise businesses and laboratories that offer analytical or diagnostic services. In addition to bigger companies such as Google and IBM, India is also host to start-up companies that specialise in harnessing AI to diagnose disease. From a review of solutions adopted it appears that diagnostics in India are employing descriptive and predictive AI.

For example, Niramai Health Analytix uses thermal analytics for early-stage breast cancer detection[51], while Advenio Tecnosys detects TB from chest x-rays and acute infections from ultrasound images[52]. Qure.Ai uses deep learning technology to help diagnose disease as well as recommend personalised treatment plans from healthcare imaging data[53], and Orbuculum uses AI to predict diseases such as cancer, diabetes, neurological disorders, and cardiovascular diseases through genomic data[54]. Cureskin diagnoses six types of common skin conditions – pimples, acne, scars, dark spots, pigmentation, and dark circles – and recommends treatment regimens through a mobile app. It claims that its deep learning algorithms are at dermatologist level accuracy for the six skin conditions it works on at present.[55]

According to the WHO, India is home to over five crore Indians suffering from depression, and is a major contributor to global suicides.[56] However, seeking help for mental health issues is still stigmatised. Firms are addressing this issue by using technology to help deal with mental health issues, usually in the form of chatbots that offer counselling while maintaining privacy.

In India, AI is being employed through chatbots such as Wysa that provide mental health support. A person can chat anonymously with an AI-enabled system, and the chatbot is intended to provide empathetic support and suggest practitioners to consult. However, these chatbots have not been designed to provide diagnosis or deal with more serious issues (these are transferred to doctors). The advantage of these chatbots is the potential anonymity and privacy they could provide if designed with a privacy enhancing approach – there is no need to sign up, and no personal information needs to be collected. Chatbots have also been presented as an interface which is non-judgmental and consequently, more empathetic towards the concerns of patients. This could encourage people to open up without hesitation.[57] One such example is the outlet provided by such apps for displaced

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49 P. Raghavan (2016, October 31), Indian pharma sector going digital at a fast pace, Retrieved January 5, 2018, from **https://economictimes.indiatimes.com/industry/healthcare/biotech/pharmaceuticals/indian-pharma-going-digital-at-a-fast-pace/articleshow/55146271.cms**

50 A. Choudhury (2017, March 10), How this Pune-based startup is automating the pharmaceutical supply chain management, Retrieved January 5, 2018, from **https://yourstory.com/2017/03/pharmarack-technologies-startup/**

51 Niramai Technology, Retrieved January 5, 2018, from **http://niramai.com/technology/**.

52 Chironx, Retrieved January 5, 2018, from **https://chironx.ai/**

53 Qure.ai, Retrieved January 5, 2018, from **http://qure.ai/**

54 Orbuculum, Retrieved January 5, 2018, from **https://www.f6s.com/orbuculum**

55 S. Sharma (2017, November 23), This AI-enabled dermatology app aims to save Indians the blushes, Retrieved January 5, 2018, from **https://factordaily.com/cureskin-ai-skincare/**

56 PTI (2017, February 24), Over 5 crore people suffer from depression in India: WHO, Retrieved January 5, 2018, from **http://www.livemint.com/Specials/Ysja8QtaVqjRpKg7eAFJfL/Over-5-crore-people-suffer-from-depression-in-India-WHO.html**

57 S. Mohandas, Centre for Internet and Society (2017, December 16). AI and Healthcare in India: Looking Forward, Retrieved January 5, 2018, from **https://cis-india.org/internet-governance/blog/ai-and-healthcare-in-india-looking-forward**.

workers from India's IT industry to vent their fears about potential job losses in the upheaval facing the industry at present.[58]

Wysa is an emotionally intelligent chatbot that acts as a mental health and behavioural coach. It uses smartphone sensors to identify and aid patients in need. Its machine learning platform collects data from mobile phones and sensors, and uses it to identify potential health problems through changes in patterns of communication, activity, and sleep (all of which are tracked via smartphone), and even warns if the user may be at risk for depression.[59] Woebot is a similar service that tracks changes in user mood on a weekly basis and finds patterns within them, offering techniques to deal with these issues.[60]

4. Medical Equipment and Supplies: This includes establishments primarily manufacturing medical equipment and supplies, e.g. surgical, dental, orthopaedic, ophthalmologic, laboratory instruments, etc. From a review of solutions adopted it appears that companies developing medical equipment and supplies in India are employing descriptive and predictive AI.

Niramai (which is an acronym for "Non-Invasive Risk Assessment with Machine Intelligence") uses a high-resolution thermal sensing device that scans the chest area like a camera, and uses cloud-hosted analytics solutions to analyse the thermal images for early signs of breast cancer.[61] Ten3T has created a wireless patch that can be worn by heart patients. This patch continuously monitors vitals and transmits this data via the cloud, which can then be tracked by doctors in real time.[62] AI is also being used to monitor patients' vital signs in ICUs, and notify the doctor in the event of any anomaly, as in the case of Philips IntelliSpace Consultative Critical Care. It can also used therapeutically, as in the Implantable Cardiovascular Defibrillator (ICD) that monitors heart rates and automatically administers shocks in case of an abnormality.

5. Medical Insurance: This includes health insurance and medical reimbursement facilities, covering an individual's hospitalisation expenses incurred due to sickness. From a review of solutions adopted it appears that companies offering medical insurance in India are employing descriptive and predictive AI.

Machine learning is able to automate claims management by analysing vast amounts of data in less time, which reduces processing time and handling costs and improves customer experience. Identifying suspicious patterns in data can also help identify fraudulent claims, which could speed up settlement of genuine claims. By combining big data with AI, insurers can identify the lifestyle habits of customers to provide them customised offerings. Big data can also be harnessed to enable insurers to identify early-stage illnesses and reduce the risk of treatment-related complications.[63] At present, insurers in India are limited to managing operations. Bajaj Allianz General Insurance uses Boing, a chatbot that addresses customer queries on motor and health insurance. ICICI Lombard uses its chatbot platform MyRA to sell insurance policies. HDFC Life's email bot Spok claims to be first in India to automatically read, understand, categorise, prioritise and respond to customer emails.[64]

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58 S. Rai, (2017, December 12), Fired tech workers turn to chatbots for counselling, Retrieved January 5, 2018, from **http://www.business-standard.com/article/companies/fired-tech-workers-turn-to-chatbots-for-counselling-117121200068_1.html**

59 Wysa AI, Retrieved January 5, 2018, from **https://www.wysa.io/**

60 Woebot, Retrieved January 5, 2018, from **https://woebot.io/**

61 Niramai Technology, Retrieved January 5, 2018, from **http://niramai.com/technology/**

62 Ten3Health, Retrieved January 5, 2018, from **http://www.ten3thealth.com/**

63 S. Mantri, (2017, September 25), Artificial Intelligence And Healthcare, Retrieved January 5, 2018, from **https://www.icicilombard.com/experts-blogs/story/artificial-intelligence-and-healthcare**

64 S. Saleem, (2017, June 20), Bots are welcome in the insurance sector, Retrieved January 5, 2018, from **http://www.livemint.com/Money/BuEJg3dxFvAR66lgd2rfTO/Bots-are-welcome-in-the-insurance-sector.html**

6. Telemedicine: Telemedicine utilises electronic communications and software to remotely provide clinical services to patients. It is frequently used for follow-up visits, management of chronic conditions, medication management, specialist consultation and other clinical services that can be provided remotely via secure video and audio connections.[65] This bypasses barriers of time and space and serves to provide isolated communities with speedy delivery of medical expertise.[66] From a review of solutions adopted it appears that companies developing telemedicine platforms in India are employing descriptive and predictive AI.

Telemedicine can help meet the challenges of healthcare delivery to rural and remote areas in addition to performing other functions in education, training and management in the health sector.[67] However, telemedicine currently faces infrastructural challenges, and is dependent on the quality of services provided by the medical professional. By doing away with the human component, AI standardizes the quality of care.

SigTuple can analyse blood slides and generate a pathology report without assistance from a pathologist. This service can be utilised in remote areas at a fraction of what it would usually cost.[68]

Microsoft has teamed up with the Government of Telangana to use cloud-based analytics for the Rashtriya Bal Swasthya Karyakram program by adopting MINE (Microsoft Intelligent Network for Eyecare), an AI platform to reduce avoidable blindness in children.[69]

The Philips Innovation Campus (PIC) in Bengaluru is harnessing technology to make healthcare affordable and accessible. They have developed solutions for TB detection from chest x-rays, and a software solution (Mobile Obstetrics Monitoring) to identify and manage high-risk pregnancies. It has partnered with Fortis Escorts Heart Institute, Delhi to set up Philips IntelliSpace Consultative Critical Care, where hospitals can now monitor multiple intensive care units (ICUs) from a central command centre that may be located in a geographically-separated area.[70]

Government Initiatives

1. National eHealth Authority (NeHA)

NeHA was proposed by the Ministry of Health and Family Welfare in 2015 as an authority to be responsible for the development of an integrated health information system in India. It will be the nodal authority that will develop an integrated health information system along with the application of telemedicine and mobile health by collaborating with various stakeholders. Apart from this, it will also be responsible for enforcing the

65 Chiron Health, What is Telemedicine?, Retrieved January 5, 2018, from **https://chironhealth.com/telemedicine/what-is-telemedicine/**

66 V. Dalmia (2013, February 12), India: Telemedicine In India - Legal Analysis, Retrieved January 5, 2018, from **http://www.mondaq.com/india/x/221258/food+drugs+law/Telemedicine+In+IndiaLegal+Analysis**

67 Vision 2K+ Inc. (2015), What is Telehealth?, Retrieved January 5, 2018, from **http://www.v2k.in/Telehealth.html**

68 S. Chakraberty. (2017, February 13), An artificially intelligent pathologist bags India's biggest funding in healthcare AI, Retrieved January 5, 2018, from **https://www.techinasia.com/artificially-intelligent-pathologist-bags-indias-biggest-funding-healthcare-ai**

69 J. Nagpal. (2017, August 3), Government of Telangana adopts Microsoft Cloud and becomes the first state to use Artificial Intelligence for eye care screening for children, Retrieved January 5, 2018, from **https://news.microsoft.com/en-in/government-telangana-adopts-microsoft-cloud-becomes-first-state-use-artificial-intelligence-eye-care-screening-children/**

70 L. D'Monte. (2017, February 16), How Philips is using AI to transform healthcare, Retrieved January 5, 2018, from **http://www.livemint.com/Science/yxgekz1jJJ3smvvRLwmaAL/How-Philips-is-using-AI-to-transform-healthcare.html**

laws and regulations relating to the privacy and security of the patients' health and information records. NeHA is proposed to be a promotional, regulatory and standards setting organization to guide and support India's journey in e-Health and consequent realization of benefits of ICT intervention in the health sector in an orderly way. Its primary objectives included the formulation of the "National eHealth Policy and Strategy" for coordinated eHealth adoption, setting up of state health records repositories and health information exchanges (HIEs) to facilitate interoperability, laying down of data management, privacy and security policies, guidelines and health records of patients, as well as developing a certification framework for HER products in collaboration with STQC. It also spells out the proposed functions and governance mechanism of NeHA.[71]

2. The Ministry of Health and Family Welfare according to news items has reportedly worked with National Law School of India University, Bangalore to prepare a draft legislation on a Health Data Privacy and Security Act Electronic which substantively deals with issues of confidentiality, privacy, ownership of health data as well as the establishment of NeHA.[72] As a note, at the time of writing this report, the researchers were unable to access a public copy of the draft legislation. As per reports, the health ministry discussed the initial draft with the legal experts from the university in June 2016, and the draft legislation was submitted to the ministry in July 2016. A senior official of the health ministry had stated that after the records have been anonymised, they will also be used for big data analytics. This also raise questions of the standards being employed for de-identification, something which has not featured prominently in of the mission documents made publicly available about the NeHA. Globally, examples of re-identification of anonymised data sets have been pointed out, especially where the anonymisation techniques are not robust enough.[73] Significant issues also exist with regard to the ownership of the data. The stated objectives of the NeHA address very important issues of lack of sufficient evidence and data in medicine in India, therefore, how this policy is formulated and the kind of powers accorded to the authority will be important for future ethical use of AI and big data in healthcare.

3. Artificial Intelligence Task Force

The 'Task Force on AI for India's Economic Transformation' was set up by the Ministry of Commerce and Industry in 2017 to explore possibilities to leverage AI for development across various fields. It will submit concrete and implementable recommendations for government, industry and research institutions. It consists of experts, academics, researchers and industry leaders, as well as government participation through representatives of the NITI Aayog, Ministry of Electronics and Information Technology, Department of Science & Technology, UIDAI and DRDO.[74]

4. Policy Group on Artificial Intelligence

The Ministry of Electronics and Information Technology has recently formed a "policy group" to study aspects of AI technology and formulate a policy framework and road map for its adoption. The policy group will consist of representatives from academia as well as NASSCOM for an industry perspective, and will focus on aspects such as privacy, security, liability and skilling the workforce.[75]

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71 National eHealth Authority (NeHA), Retrieved January 5, 2018, from **https://www.nhp.gov.in/national_eHealth_authority_neha_mtl**

72 P. Raju. (2016, October 8), 'We are working in the direction of citizen empowerment through information dissemination', Retrieved January 5, 2018, from **http://www.expressbpd.com/healthcare/it-healthcare/we-are-working-in-the-direction-of-citizen-empowerment-through-information-dissemination/377474/**

73 Ohm, Paul (2009 August 13), Broken Promises of Privacy: Responding to the Surprising Failure of Anonymization Retrieved January 5, 2018, from **https://ssrn.com/abstract=1450006**.

74 Artificial Intelligence Task Force, Retrieved January 5, 2018, from **https://www.aitf.org.in/**

75 PTI (2017, September 13), Centre forms policy group to study artificial intelligence: Nasscom, Retrieved January 5, 2018, from **https://economictimes.indiatimes.com/tech/internet/centre-forms-policy-group-to-study-artificial-intelligence-nasscom/articleshow/60499213.cms**

5. National IPR Policy

In 2016, the Department of Industrial Policy and Promotion ("DIPP") released the NIPR themed 'Creative India; Innovative India', which focuses on creating awareness on the importance of IPR as a marketable financial asset and economic tool. It lays down seven broad objectives ranging from awareness creation to strengthening enforcement and adjudication mechanisms for combating infringement. The NIPR recognizes the potential for innovation that exists in new and emerging technologies and talks about developing novel technology platforms in order to ensure enhanced access to affordable medicines and other healthcare solutions.[76]

6. United States–India Science & Technology Endowment Fund (USISTEF)

The governments of the United States of America (through the Department of State) and India (through the Department of Science & Technology) have established the United States–India Science & Technology Endowment Fund (USISTEF) for the promotion of joint activities that would lead to innovation and entrepreneurship through the application of science and technology.[77] Grants of upto INR 25 million are awarded to bi-national teams of entrepreneurs and innovators who have an innovative product beyond the idea stage with a high societal impact and the potential to commercialise within 2-3 years. Priority areas include biomedical devices and diagnostics, and preventive and curative measures to improve health.[78]

7. Cognitive Science Research Initiative (CSRI), Department of Science & Technology

The Cognitive Science Research Initiative was initiated in 2008 as a platform to enable the scientific community to deal with challenges related to cognitive disorders and social issues through the use of psychological tools & batteries, early diagnosis & better therapies, intervention technologies and rehabilitation programmes.[79]

The CSRI provides funding to promote cutting edge research around different components of cognitive science, including artificial intelligence. This funding, in the form of individual research grants and Post-Doctoral Fellowships, is available to scientists and academicians working in India.[80]

8. Biotechnology Ignition Grant Scheme (BIG), Biotechnology Industry Research Assistance Council

The Biotechnology Industry Research Assistance Council (BIRAC) is the nodal funding agency of the Government of India for the biotech industry. BIG was conceptualised by BIRAC in 2012 to address issues faced by startups in the sphere of biotechnology and medical devices due to long gestation periods and market uncertainty. The scheme enables innovators to establish and validate proof of concept (POC) for high-risk, potentially high-impact

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76 National Intellectual Property Rights Policy (2016, May 12), Retrieved January 5, 2018, from **http://dipp.nic.in/sites/default/files/National_IPR_Policy_English.pdf**

77 United States–India Science & Technology Endowment Fund, Retrieved January 5, 2018, from **http://www.usistef.org/**

78 United States–India Science & Technology Endowment Fund Commercializing Technologies for Societal Impact Call For Proposal, Retrieved January 5, 2018, from **http://www.usistef.org/pdf/Endowment-Flyer-8thCall.pdf**

79 Department of Science and Technology: Cognitive Science Research Initiative (CSRI), Retrieved January 5, 2018, from **http://dst.gov.in/cognitive-science-research-initiative-csri**

80 Department of Science and Technology: Cognitive Science Research Initiative (CSRI) Individual Research Proposal, Retrieved January 5, 2018, from **http://dst.gov.in/sites/default/files/CSRI-AD-2017.pdf**

technological ideas in order to eventually commercialise or implement them.[81] The scheme currently works across the country through five BIG Partners who mentor and monitor the grantees. Grant money amounting to INR 821.96 lakhs (USD $ 1.6m) has been approved for the scheme. Since 2012, BIG has supported more than 200 biotech and healthcare startups.[82]

9. Centre of Excellence for Data Science and Artificial Intelligence (CoE-DS&AI)

The Government of Karnataka, in collaboration with NASSCOM, is setting up a Centre of Excellence for Data Science and Artificial Intelligence (CoE-DS&AI)[83] at an estimated cost of INR 40 crore on a public-private partnership model to "accelerate the ecosystem in Karnataka by providing the impetus for the development of data science and artificial intelligence across the country" and position is as one of the top five global innovation centres in AI over the next five years.

The Centre will work with partner organisations to expand AI capacity across academia, the government, and businesses by investing technological infrastructure and industry-oriented research, equipping academic institutions to provide education and skill development in DS and AI, encouraging innovation and adoption of data-driven decision making by enterprises and government.

Stakeholders in the AI and Healthcare Ecosystem

There are a number of stakeholders that make up the healthcare ecosystem and work together towards the successful adoption and implementation of AI in healthcare. In order to map the stakeholder ecosystem, we began by identifying the key stakeholders that have an impact on the AI and healthcare industry. The stakeholders were divided into five categories: practitioners, developers, research and industry bodies, government, and funders and investors. The developer mapping was further categorized on the basis of the type of company, sector and AI solution offered. The mapping also covered the various conferences that were held in India on topics relating to AI and health. The data about the stakeholders was derived from publicly available information on websites, and newspaper reports, after which the data was further categorized. The list of stakeholders identified as well as a brief summary of our findings is as presented below. See Annex 1 for complete mapping.

Practitioners: Through our study, we identified fourteen hospitals incorporating the technology into their systems and practices. In the hospitals identified, the most common use of AI was for diagnosis and patient monitoring. Hospitals like Tata Memorial Hospital provided data to Indian startups, based on an approval from their internal ethics committee.[84] Manipal Hospitals has teamed up with IBM to use Watson for Oncology to provide cognitive assistance. LV Prasad Eye Institute (LVPEI), Narayana Nethralaya (Bangalore), Sankara Nethralaya (Chennai))are using Google's algorithms and AI technology for detecting referable diabetic retinopathy. Fortis Hospitals have also partnered with GE healthcare to provide a tele-intensive care unit (ICU) for management of critically ill patients in small towns.

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81 Biotechnology Ignition Grant (BIG), Retrieved January 5, 2018, from **http://birac.nic.in/webcontent/BIG_Guidelines_01_01_2017.pdf**

82 J. Vignesh (2017, February 17), Biotech startups: Govt steps in where investors fear to tread, Retrieved January 5, 2018, from **https://economictimes.indiatimes.com/small-biz/security-tech/technology/indias-big-revolution/articleshow/57200541.cms**

83 NASSCOM (2017, November 16), Government Of Karnataka And Nasscom Partner To Launch Centre Of Excellence For Data Science And Artificial Intelligence, Retrieved January 5, 2018, from **http://www.nasscom.in/sites/default/files/media_pdf/government-of-karnataka-and-nasscom.pdf**

84 Rangasai, A. (2017, December 15). Personal Interview.

Researchers and industry bodies: With regard to research in the field of AI and health, our study identified seventeen organizations involved in the research of AI and healthcare. The individuals ranged from professors from IITs to scientists like Dr. Anurag Agrawal who is the Principal scientist at the CSIR Institute of Genomics & Integrative Biology (IGIB) as well as a member of the AI task force. The industrial bodies that are instrumental in research in this field are PricewaterhouseCoopers (PWC) and Ernst & Young (EY) that have published reports on the topic of technology and health in India as well as associations such as the Confederation of Indian Industries and the Federation of Indian Chambers of Commerce and Industry.

Government: The government of India has taken its first step towards understanding AI by setting up the AI task force, which also includes individuals in the field of medicine. In our study we identified seventeen government bodies that are stakeholders or have a significant role to play in AI and healthcare in India. Some of the stakeholders identified include the Medical Council of India, The Ministry of Electronics and Information and Technology and the Ministry of Health and Family Welfare. The Ministry of Health and Family Welfare has also taken a step to standardising Electronic health records (EHR). The Ministry has also proposed to set up The National eHealth Authority, (NeHA) which is to be a promotional, regulatory and standards-setting organization in the field of healthcare. Among the departments The Department of Science and Technology and the Department of Biotechnology have been instrumental in providing funds to startups working on AI and health.[85] With regard to the state governments the Government of Telangana was reported to be working with Microsoft India to adopt a cloud-based analytics care screening program for children.

Funders/Investors: The startups working on AI and health in India have been funded by various investors that are interested in the potential for AI and health in India. Our study identified thirty investors/funders who have funded various AI and health startups in India. Sequoia, Kalari Capital, Omidyar Network, Bill and Melinda Gates Foundation, and YourNest Angel Fund are some of the investors. The Department of Biotechnology is one of the few government bodies that have funded AI and health startups in India.

Developers: In our attempt to map significant developers of AI solutions in the Indian healthcare space, we were able to identify forty four companies that have dedicated their resources to developing unique AI based solutions which are capable of catering to the diverse needs of the medical industry and its many customers. The focus area of these developers ranged from dermatology to greatrics, to drug development and even software as a service. Our study identified thirty six domestic companies and eight international companies. The focus areas of the companies ranged from Genetic counseling and preventative healthcare, e-teaching, to health management to customer services such as chatbots. Out of the fifty four companies, seventeen companies were in the field of diagnostics, one company dealt with medical equipments, nineteen companies that provide telemedicine services, and four companies in the field of drug discovery and pharmaceuticals. Microsoft India, IBM, Philips, Google and MITRA Biotech are some of the major international companies that are contributing to the development of AI based diagnostics and telemedicine solutions. Among the domestic companies, a majority of which were startups, we found that they were using AI for diagnosis. Some of the companies identified in the study were Nirmani, SigTuple, Tricog Health Services, and Predible. Mobile Apps such as Practo, and OnliDoc, having also been making significant headway in the telemedicine sector. In the field of drug discovery Bioxcel was identified as one of the companies working in the sector.

85 S. Mohandas, Centre for Internet and Society (2017, December 16). AI and Healthcare in India: Looking Forward, Retrieved January 5, 2018, from **https://cis-india.org/internet-governance/blog/ai-and-healthcare-in-india-looking-forward**.

Ethical, Legal, and Cultural Considerations

The importance of responsible and ethical AI has been highlighted by experts.[86] Though there is potential for AI to transform healthcare in India, ethical, legal, and cultural factors need to be considered by developers, practitioners, and policy makers when designing, using, and regulating AI. How can AI systems ensure consent? How will questions of liability be addressed? How does AI fit into existing ethical frameworks in India? How can the security and accuracy of AI solutions be ensured - particularly in the health sector as individual lives can be at stake and highly sensitive data is being handled.

Potential ethical, legal, and cultural concerns around AI in healthcare include:

1. **Cultural Acceptance**: This is often a roadblock in AI acceptance in terms of 'trust issues' that patients may have such as wanting doctors to be physically present, or the elderly who may be more averse to adopting new technology. Different cultural norms must also be accounted for, and tasks carried out by machines must be culture-specific depending on the country or region where it is deployed.[87]
   Similar thoughts were expressed by the team at Wysa, where overcoming the cultural perceptions of trust, especially in India, was a key barrier is acquiring new users. For instance, negative press reports claiming that AI poses a threat to jobs result in difficulty for startups to acquire funding.[88] Moreover, the lack of technological infrastructure in India means that AI still lacks the deep-learning capabilities that can overcome linguistic diversity across the country[89], which may be a major impediment in the adoption of AI, especially in primary healthcare.

2. **Defining Acceptable Behaviour**: 'Acceptable behaviour' for an AI system must be clearly defined for its respective application domain, and should ideally drive design considerations, engineering techniques and reliability. AI technologies must perform in an easy to understand manner and the outcome from their applications should in line with the perception of fairness, equality and local cultural norms to ensure broad societal acceptance.
   In the context of the use of AI in healthcare, norms must be established to deal with confidentiality in the doctor-patient - AI relationship, informed consent (for different procedures and use/access of personal data - health related and beyond), and standards for AI driven medical research.
   Doctor-patient confidentiality has been codified in the MCI Code of Ethics Regulations, 2002 which sets the professional standards for medical practitioners. Physicians are obligated to protect the confidentiality of patients, including their personal and domestic lives, unless the law requires their revelation, or if there is a serious and identified risk to a specific person and/ or community, or notifiable disease.[90] However, the Bombay High Court in *Mr. Surupsingh Hrya Naik v. State of Maharashtra*[91] has held that the Right to Information Act would prevail over the MCI Regulations, as it is a subordinate legislation. Provisions relating to confidentiality are also outlined in other healthcare-

86 F. Zamin-Malik (2017, September 15), Let's Get A Grip On Artificial Intelligence In Healthcare, Retrieved January 5, 2018, from **https://www.accenture.com/us-en/blogs/blogs-lets-get-grip-artificial-intelligence-healthcare**

87 T. Simonite (2017, March 30), Tech Giants Grapple with the Ethical Concerns Raised by the AI Boom, Retrieved January 5, 2018, from **https://www.technologyreview.com/s/603915/tech-giants-grapple-with-the-ethical-concerns-raised-by-the-ai-boom/**

88 R. Vempati, (2018, January 16). Personal Interview.

89 S. Vempati (2016, August), India And The Artificial Intelligence Revolution, Retrieved January 5, 2018, from **http://carnegieendowment.org/files/CP283_Vempati_final.pdf**

90 Indian Medical Council (Professional Conduct, Etiquette and Ethics) Regulations, 2002.

91 AIR 2007 Bom 121 (Bombay High Court).

related legislation including the Mental Healthcare Act, 2017[92], the Medical Termination of Pregnancy Act, 1971[93] and the EHR Standards, 2016[94].

3. **Data Safety/ Privacy**: Hackers can exploit AI solutions to collect private and sensitive information such as Electronic Health Records. Machine learning algorithms can also be misused to develop autonomous techniques that jeopardise the security and safety of such vital information. AI systems can challenge privacy through real time collection and use of a multitude of data points that may or may not be disclosed to an individual in the form of a notice with consent taken.
   In 2016, the hacking of a Mumbai-based diagnostic laboratory database led to the leaking of medical records (including HIV reports) of over 35,000 patients. This database held the records of patients across India, and many may be unaware that their details have been exposed. The database had been the victim of multiple hacks in the previous few months, sometimes upto thrice a week. However, no action had been taken by the laboratory to secure the data.[95]
   This highlights the need for higher privacy and security standards regulating sensitive personal information in India and the need for requirements such as breach notification. Globally, the Institute of Electrical and Electronic Engineers (IEEE) has formulated an ethically aligned design initiative for autonomous and intelligent systems.[96] It attempts to define and lay down the bare minimum principles that developers and designers should bear in mind while making autonomous systems.
   The Ministry of Health and Family Welfare is working on a sector-specific legislation, tentatively called the Healthcare Data Privacy and Security Act. In addition to the EHR Standards, this law will reportedly provide civil and criminal remedies for breach of data, will prescribe principles for data collection and use, and will provide for interoperability with private hospitals.[97]
   The team at Wysa chooses to deal with the issues of data privacy by making all interactions with the application anonymous. No data about the name, age location or other personal identifiers is necessary to begin using the application (which allows for anonymous sign ups) and none of the data gleaned from the sensors and interactions with the users is tagged to any data that can identify them in anyway. This minimises most risks and inculcates a more trusting relationship between the chatbot and its users.[98]

4. **Explainable**: AI algorithms may be inherently subject to errors that can lead to consequences such as unfair outcomes for racial and economic classes. AI system actions should therefore be explainable and easily understandable by humans. This is especially important in healthcare, where diagnosis and treatment need to be backed by a solid chain of reasoning to earn patient trust.
   The MCI Regulations require that medical consultations shall be conducted for the

92 The Mental Healthcare Act, 2017.

93 The Medical Termination Of Pregnancy Act, 1971.

94 Electronic Health Record (EHR) Standards for India (2016).

95 ENS (2016, December 3), Maharashtra website hacked: Diagnostic lab details of 35,000 patients leaked, Retrieved January 5, 2018, from **http://indianexpress.com/article/india/diagnostic-lab-details-of-35000-patients-leaked-hiv-reports-4407762/**

96 The IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems, Retrieved January 5, 2018, from **http://standards.ieee.org/develop/indconn/ec/autonomous_systems.html**

97 A. Deo (2017, January 26), Without Data Security and Privacy Laws, Medical Records in India Are Highly Vulnerable, Retrieved January 5, 2018, from **https://thewire.in/102349/without-data-security-and-privacy-laws-medical-records-in-india-are-highly-vulnerable/**

98 R. Vempati, (2018, January 16). Personal Interview.

patient's benefit, and the physician shall be frank with the patient and his attendants. In case of any variation in treatment than agreed during the consultation, the reasons for such a variation shall be explained at the next consultation. In vitro fertilisation or artificial insemination shall only be undertaken with the informed written consent of the female patient, her husband and the donor. This involves providing sufficient information about the purpose, methods, risks, inconveniences, disappointments of the procedure and possible risks and hazards at the level of comprehension of the patient.[99]
To avoid the danger of AI black boxes, explainable AI must be central to responsible AI.[100] This is particularly true as doctors begin to rely more and more on AI to inform their decisions and actions.
At present, there is little guidance around when and how to provide explainability. Some factors to be accounted for are[101]:

a. What is the range of factors that AI bases its decisions on?
b. What are the desired outcomes, and how are needs prioritised as the AI makes its decisions?
c. How is the acceptable level of responsibility and liability for the stakeholders in AI determined?
d. Is the logic of a decision taken or recommended by an AI system clear and inline with best practice? can this be understood by a doctor?

5. **Consent**: Informed consent has been seen as the key ethical requirement for medical treatment and research, to be supported by requirements for professional confidentiality and personal privacy. Informed consent is particularly difficult to determine in medical practice, as even patients who are capable of making rational decisions may be influenced by their own feeling of distress and readily agree to the opinions of medical professionals who seem to be more knowledgeable, whose may wield some influence, and whom they may not want to offend.
The enthusiasm to adopt new technology may sometimes lead to the overlooking of data privacy risks and concerns. For instance, Google DeepMind's work with the Royal Free Hospital London led to criticism that users were not properly informed about how and what data would be shared with Google.[102]
In India, the doctor-patient relationship is usually one where the doctor is held in high authority and bestowed with complete trust. This is especially true with a significant part of the population handicapped by illiteracy and poverty. This problem is compounded by the fact that a large part of the population falls outside of the ambit of formally recognised medical systems, rendering the issue of obtaining informed consent moot.[103] This issue was recognised by the Supreme Court in *Samira Kohli v. Dr. Prabha Manchanda*[104] which stated that many patients in India fall below the poverty line without

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99 Indian Medical Council (Professional Conduct, Etiquette and Ethics) Regulations, 2002.

100 D. Santiago, and T. Escrig (2017, July 28), Why explainable AI must be central to responsible AI, Retrieved January 5, 2018, from **https://www.accenture.com/us-en/blogs/blogs-why-explainable-ai-must-central-responsible-ai**

101 F. Zamin-Malik (2017, September 29), Ironing Out The Ethical Snags Of Ai In Healthcare, Retrieved January 5, 2018, from **https://www.accenture.com/us-en/blogs/blogs-ironing-out-ethical-snags-ai-healthcare**

102 MESM, AI, big data and clinical trials - thoughts on the collaboration between Google's DeepMind and Moorfields Eye Hospital, Retrieved January 5, 2018, from **https://www.mesm.com/blog/ai-big-data-and-clinical-trials-thoughts-on-the-collaboration-between-google-s-deepmind-and-moorfields-eye-hospital/**

103 K. Mathiharan (2014), Law on consent and confidentiality in India: A need for clarity, Retrieved January 5, 2018, from **http://archive.nmji.in/archives/Volume-27/Issue-1/27-1-SFM-III.pdf**

104 (2008) 2 SCC 1 (Supreme Court of India).

access to ready medical care, and thus have no choice but to accept any treatment without question. Thus it is clear that there are a number of dynamics within the Indian context that impact the nature of consent given by a patient. The MCI Regulations state that informed consent must be obtained from the patient, spouse or guardian (if the patient is a minor) before performing a procedure. Publication of photographs or case studies for research requires prior consent, unless the identity of the patient cannot be established. As per section 43A and associated Rules[105] under the IT Act, body corporate collecting SPDI (which includes medical records and history) must take consent from the data subject prior to collection of the data.

6. **Liability**: In case of error in diagnosis malfunction of a technology, or the use of inaccurate or inappropriate data the question arises of who the liability would fall upon – the doctor or the software developer. In cases of medical negligence in India, liability falls on the medical professional, who can be prosecuted under civil and criminal law.[106] Since software and code are not technology agnostic, many believe that the creator of the software should be an agent that can be regulated.[107] Additionally, how does one determine the level of accountability of the doctor when he provides the wrong treatment or diagnosis due to a glitch in the system or an error in data entry? Even though he may not be at fault, liability will fall on him rather than the technology that he has relied upon. As a result of such issues of trust and liability and the current capability of AI, completely replacing medical professionals with AI (i.e. active assistance by AI) is unfeasible at present.[108]

7. **Data Integrity**: The accuracy and completeness of data sets used to power AI solutions are key to accurate and unbiased results. Data integrity will need particular attention in the Indian context as a large number of data sets are unstructured and the population is diverse. There is also the potential for specific cultural biases such as caste and sexuality to be carried forward in data sets. Thus it is important that the data and input sources on which the AI technology's algorithms are based and trained on are derived from a sufficiently large and diverse population.

8. **Algorithmic Accountability**: The accurate and unbiased architecture of an AI solution and its underlying algorithm is also important in ensuring responsible AI. Adaptability, consistency, accountability, and monitoring are aspects that ensure an algorithm is learning from its mistakes and successes, it is incorporating new medical findings, demographic changes, and technological developments, and it is conforming to prevalent medical and healthcare standards. As India considers a data protection framework, appropriate forms of oversight over algorithms has been discussed, with one proposal suggesting an accountability model with a learned intermediary that would audit algorithms to ensure they are privacy neutral. The audit would include– *(i) Database Query Review; (ii) Black Box Audits; and (iii) Algorithm Review*.[109] Inclusion and an explicit attempt to limit exclusionary actions is also an obligation that some stakeholders have claimed should be present within such an accountability framework.[110]

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105 Information Technology (Reasonable security practices and procedures and sensitive personal data or information) Rules, 2011.

106 K. Murthy (2007), Medical negligence and the law, Retrieved January 5, 2018, from **http://ijme.in/articles/medical-negligence-and-the-law/?galley=html**

107 S. Mohandas, Centre for Internet and Society (2017, December 16). AI and Healthcare in India: Looking Forward, Retrieved January 5, 2018, from **https://cis-india.org/internet-governance/blog/ai-and-healthcare-in-india-looking-forward**.

108 Dr. Agrawal, A. (2017, November 24). Personal Interview.

109 R. Matthan, Beyond Consent: A New Paradigm for Data Protection (2017, July). Retrieved January 5, 2018, from **http://takshashila.org.in/wp-content/uploads/2017/07/TDD-Beyond-Consent-Data-Protection-RM-2017-03.pdf**

110 R. Vempati, (2018, January 16). Personal Interview.

Policy and Regulatory Landscape in India

There are many policies in India that impact different aspects of the development and use of artificial intelligence in healthcare. This includes regulation around how health data can be used, certification of digital medical devices, standards around digital medical devices, and frameworks around patient/relationships. The Government of India has also undertaken a number of policy initiatives that could incentivise the development of AI and health solutions. Below is an outline of relevant Indian law, policy, and standards:

Information Technology Act, 2000; Information Technology (Reasonable Security Practices and Procedures and Sensitive Personal Data or Information) Rules, 2011

The use of these new technologies requires a constant exchange of information between the patient and the service provider. The patient's personal information, such as medical history and physiological conditions, are considered Sensitive Personal Data or Information ("SPDI") under the Data Protection Rules ("Rules"), of which certain provisions apply when a body corporate collects, stores, transfers or processes such information.

Consent is a clear requirement under the Rules. Therefore, a doctor or an institution must obtain a patient's written consent before using their data. The patient must be informed if any data is being collected along with the purpose of collection, and of any transfer of such information to third parties and details of the information collection agency. The body corporate transferring the SPDI must ensure that the receiver of the SPDI has adequate security practices in place. The body corporates must also publish a privacy policy on its website. The Rules also mandate the implementation of reasonable security practices and procedures in order to keep the SPDI secure - of which ISO 27001 is an accepted standard.

The Rules also contain requirements to appoint a 'Grievance Officer' whose contact details are to be published on the website, as well as the provision to allow users to opt-out or modify their SPDI if required.

However, despite the existence of these rules, there has been minimal compliance in India due to lack of enforcement mechanisms. Questions have also been raised about the legislative scope of these rules which while drafted under a data security provision, may be seen as going beyond its scope.

The Supreme Court in K.S Puttaswamy & Anr. v. Union of India & Ors.[111] outlined the need for a comprehensive data protection framework, due to which the Ministry of Electronics and Information Technology constituted a committee of experts chaired by Justice B.N. Srikrishna to identify data protection issues and make recommendations to address them, as well as prepare a draft legislation to be introduced in Parliament.[112]

The Indian Medical Council Act, 1956 ("MCI Act") and The Indian Medical Council (Professional conduct, Etiquette and Ethics) Regulations, 2002 ("MCI Code")

The MCI Code lays down professional and ethical standards of interaction of doctors with patients which include patient confidentiality and disclosure of prognosis. The Code also specifies that efforts are to be made to computerise medical records so that they can be retrieved quickly. The apex body currently regulating the practice of medicine is the Medical Council of India. However, the proposed National Medical Commission Bill, 2016 which has been drafted by the NITI Aayog intends to replace the current Medical Council of India with a 'National Medical Commission'. The passing of the National Medical Commission Bill would see a change in the current regulatory framework regulating medical practitioners.

111 Writ Petition (Civil) No 494 of 2012 (Supreme Court of India).

112 Office Memorandum for the Constitution of a Committee of Experts to deliberate on a data protection framework for India (2017, July 31), Retrieved January 5, 2018, from **http://meity.gov.in/writereaddata/files/meity_om_constitution_of_expert_committee_31072017.pdf**

Electronic Health Records Standards, 2016

The EHR Standards, 2016[113] are an attempt to regulate data ownership and privacy standards around the storage of health data collected from patients. This includes data from medical establishments as well as data from medical devices and self-care devices and systems. The government has recognised the need for standardisation of such data, and has accordingly laid down standards relating to information capture, storage, retrieval, exchange and analytics, including images, clinical codes and data. These include ISO and other national standards to be used for EHRs.

- **Data Ownership**: Although data generated by patients can be stored by providers, it will be owned by customers. Patients shall be able to view these medical records without any time restrictions.
- **Data Access**: Patients are in complete control of who can access data, and shall explicitly consent to disclosures. They shall also be able to correct any errors in their medical records.
- **Changes to Data**: Data cannot be changed once it is entered into the system. Any necessary changes must be accompanied by an audit trail, and changes to previously saved data are not permitted. Records requiring changes shall be made on a new medical record containing the revised data, which shall then be marked as "active".
- **Disclosure of Health Information**: Specific consent of the patient is required for use in non-routine and non-healthcare purposes. However, data can be freely disseminated without permission after removing any personal identifiers.
- **Access to Records by Courts/ Government Authorities**: Health records must be produced in an "as-is" state in case of a court order. Additionally, health information can be revealed without consent to the appropriate authorities according to the law in case of national issues such as notifiable/ communicable disease.
- **Responsibility of Healthcare Providers**: Healthcare providers shall be responsible for storage of patient information and ensuring removal of personal identifiers. They must also inform patients about their rights, and take measures to ensure privacy of such data. They can also deny information to patients if a licensed doctor believes that releasing such information could endanger the life and safety of the patient or others. Electronic Records must not be destroyed even after the death of a patient, but they can be moved from active to inactive status if there are no pending court cases that require this data.
- **Encryption of Data**: Electronic health records must compulsorily be encrypted with a minimum of bit encryption keys. Secure transmission standards must be used while transferring such data between sites. All action pertaining to the data must be recorded.
- **Identification**: If the patient's Aadhaar number is available, it must be used as a unique identifier, in the absence of which two government ID cards can be used instead.

Open Data Policy

The National Data Sharing and Accessibility Policy (NDSAP) was formulated by the Ministry of Science and Technology and implemented by the Ministry of Electronics and Information Technology in the form of an Open Data Platform.[114] The NDSAP is designed to enable the sharing of non-sensitive data which has been generated using public funds, and is either in digital or analogue form.[115] Access to this data is open, registered or restricted depending on the level of authorisation required.

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113 Electronic Health Record (EHR) Standards for India (2016).

114 Open Government Data (OGD) Platform India. Retrieved January 5, 2018, from **https://data.gov.in/**

115 National Data Sharing and Accessibility Policy (NDSAP) 2010, Retrieved January 5, 2018, from **https://data.gov.in/sites/default/files/NDSAP.pdf**.

The majority of the healthcare indicators on the Open Data Portal is from the Health Management Information System (HMIS), but studies have called into question its accuracy.[116] The data available on the website is public sector data, however almost 70% of healthcare is limited to the private sector.[117] This raises doubts about how representative the available data is. Startups without access to large datasets face the challenge of not having enough data for prototyping.[118] As open data is an important enable to AI, India needs to open up more data, as well as incentivise private healthcare providers to provide anonymised data.

The health data provided at present is aggregated and does not give anonymised granular data. This can be contrasted with the UK, where the National Health Service works together with private entities to provide machine-readable open data and formulate organisational policies around open data and transparency agendas.[119] The UK NIH Clinical Centre recently released over 100,000 anonymized chest x-ray images and their corresponding data from more than 30,000 patients to the scientific community. All patients are partners in research and voluntarily enroll to participate in clinical trials.[120] In Israel, health records are digitised and provided to Israeli startups by the government (with prior government approval if the startups can provide proof of use).[121] In the USA, the American Cancer Society (a non-government body) which has access to large-scale cancer datasets, releases this data for free use by anyone along with interactive tools to work with this data.[122]

Medical Devices Rules, 2017

The Medical Device Rules, 2017 have been drafted with the intention to distinguish between medical devices and pharmaceuticals for the purpose of regulation. The Rules define what shall be classified as medical devices, and the scope of these Rules is limited to those devices that fall within its ambit. The Rules have introduced a risk-based classification system, which categorises medical devices into Low (Class A), Low Moderate (Class B), Moderate High (Class C) and High (Class D). Classification according to risk shall be carried out by the manufacturers in accordance with the framework decided by the Drug Controller General of India.

In order to obtain a grant of license to manufacture these medical devices, Class A medical devices do not require prior audit by third party or official inspection; Class B medical

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116 Pandey, Arvind & Roy, Nandini & Bhawsar, Rahul & Mishra, Ram. (2010). Health Information System in India: Issues of Data Availability and Quality. Retrieved January 5, 2018, from **https://www.researchgate.net/publication/232084914_Health_Information_System_in_India_Issues_of_Data_Availability_and_Quality_1**

117 A Health Survey Indicates that During 15 Day Reference Period 89 Per 1000 Persons Reported Illness in Rural India Against 118 Persons in Urban Areas. However, Un-Treated Spell Was Higher in Rural (Both for Male and Female) than Urban Areas, Retrieved January 5, 2018, from **http://pib.nic.in/newsite/PrintRelease.aspx?relid=122888**

118 S. Mohandas, Centre for Internet and Society (2017, December 16). AI and Healthcare in India: Looking Forward, Retrieved January 5, 2018, from **https://cis-india.org/internet-governance/blog/ai-and-healthcare-in-india-looking-forward**.

119 NHS Englad, Open Data, Retrieved January 5, 2018, from **https://www.england.nhs.uk/ourwork/tsd/data-info/open-data/**

120 National Institutes of Health (2017, September 27), NIH Clinical Center provides one of the largest publicly available chest x-ray datasets to scientific community, Retrieved January 5, 2018, from **https://www.nih.gov/news-events/news-releases/nih-clinical-center-provides-one-largest-publicly-available-chest-x-ray-datasets-scientific-community**

121 Rangasai, A. (2017, December 15). Personal Interview.

122 American Cancer Society, Retrieved January 5, 2018, from **https://cancerstatisticscenter.cancer.org/#!/**.

devices require prior audit by a third party but do not require official inspection, and Class C or Class D medical devices require prior official inspection. Devices are expected to conform to either to the standard laid down specifically for the device by the central government or by the Bureau of Indian Standards, in the absence of which they must conform to standards laid down by the International Organisation for Standardisation or the International Electro Technical Commission, among others. These provisions provide clarity on the product standards for medical devices.

Other provisions include certainty of timelines for decision on an application and within what time period one can expect an audit or inspection to be conducted, the granting of perpetual licenses (that shall remain valid until cancelled), making the licensing process easier, and mandatory recalls in case of knowledge of risk to health.

The Rules do not contain separate provisions for sale of medical devices. However, they address a practical difficulty encountered by distributors in India, aka stock transfers which are merely a transfer of stock and not a sale. The hospital is charged as per use, and remaining stock is returned to the distributor. A stock transfer is usually not recorded by a distributor. The Rules therefore allow the supply of implantable medical devices against a delivery note (challan).

The Rules establish a new regulatory framework with regard to clinical investigation of medical devices. A timeline of 90 days has been fixed for the licensing authority to decide on an application to conduct a clinical trial. The Rules have introduced the concepts of 'Pilot Study' which is an exploratory study, and 'Pivotal Study' which is a confirmatory study, and 'substantial equivalence' with respect to approval of medical devices other than investigational medical devices.

ISO 13485:2016

ISO 13485 is an international standard that outlines quality management systems for manufacturers, suppliers, contract service and distributors of medical devices and equipment. Its main objective is to regulate medical devices through uniform quality management system requirements, and forms the basis for regulatory compliance in local and most global markets.[123]

An organization that intends to meet this standard must be able to demonstrate its ability to provide medical devices and related services that can consistently meet customer and regulatory requirements. An organization could be a part of one or more stages of the life-cycle of the product and the standard applies to such organizations regardless of their size and type unless expressly specified. The standard itself can be used by suppliers or third parties that offer quality management related services to the organization in question. As India continues to develop a framework around medical devices, this standard is being incorporated through IS 15579:2005 which is India's attempt to move towards ISO 13485:2016. The Bureau of Indian Standards has reportedly stated that IS 15579:2005 and ISO 13485:2016 are identical except for a national foreword and minor editorial changes. Unlike its international counterpart, IS 15579:2005 may be mandatory.[124]

International Landscape:

1. UK

In a bid to boost the growth of AI in the country, the UK government commissioned a review to suggest recommendations that can be adopted to regulate AI. However, instead of proactive regulation of AI, the review calls for the creation of an AI Council as an oversight body, and Data Trusts to establish a framework for technology. The review specifically

123 ISO 13485:2016. Retrieved January 5, 2018, from **http://www.isoindia.org/iso_ISO_13485.php**

124 R. Paddock (2010, January), Medical Device Regulatory Profile for India, Retrieved January 5, 2018, from **https://www.trade.gov/td/health/indiaregs.pdf**

identifies the barriers to AI in healthcare as privacy and protection of sensitive health data, as well as consumer and regulatory acceptance.

These recommendations broadly deal with[125]:

Improving access to data

The government and industry should work together to develop Data Trusts (i.e. proven and trusted frameworks and agreements) to facilitate secure and mutually beneficial exchanges of data between organisations that hold data and those that seek to use it to develop AI. The government should also explicitly require that publicly-funded research publishes underlying data in machine-readable formats with clear rights information, which is open as far as possible in order to make data available to develop AI systems. In order to support text and data mining as a standard research tool, the government should establish that by default, the right no read is also the right to mine data, as long as it does not create a product that can substitute the original work.

Improving supply of skills

The government, industry and academia should foster diversity in the AI workforce, and collaborate to release public information that counters misconceptions around AI and broadens participation. There should be a strong push for academic programmes focussing on AI, both at the Masters as well as Doctoral levels, funded by industry, universities and the government.

Maximising UK AI research

The Alan Turing Institute should be designated as a national institute for artificial intelligence and data science, with its key stated aim centered around artificial intelligence. Universities should use clear, accessible and common policies to license IP and form spin-out companies, and various national research institutes should work together to coordinate demand for computing capacity for AI research and negotiate for the national research community.

Supporting uptake of AI

The UK AI Council, established by the government along with industry and experts, will oversee AI in the country. In order to improve transparency and accountability, the Information Commissioner's Office and the Alan Turing Institute should develop a framework to explain the processes, services and decisions delivered by AI. In order to encourage the uptake of AI in business, the government should expand its current support programme for AI businesses and develop practical guidance on the opportunities and challenges of AI adoption across the economy. It should also try to set funded challenges which use public sector data for AI. The public sector must also be prepared to apply AI to provide better services to citizens.

At present, there are no regulations that deal specifically with the use of AI in healthcare. The Caldicott Guidelines[126] provide a common law framework on patient confidentiality, and states that while providing "direct care", doctors do not have to notify patients when their data is shared. However, as in the recent case of the Royal Free Hospital being reprimanded by the Information Commissioner's Office (ICO) for using patient data to test AI technology[127], testing an AI application prior to use in patient care may not qualify as

125 W. Hall, and J. Pesenti, Growing The Artificial Intelligence Industry In The UK (2017), Retrieved January 5, 2018, from **https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/652097/Growing_the_artificial_intelligence_industry_in_the_UK.pdf**

126 W. Lea (2013, March), Information: To share or not to share? The Information Governance Review, Retrieved January 5, 2018, from **https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/192572/2900774_InfoGovernance_accv2.pdf**

127 Data Protection Act 1998 Undertaking. Retrieved January 5, 2018, from **https://ico.org.uk/media/action-weve-taken/undertakings/2014352/royal-free-undertaking-03072017.pdf**

"direct care". However, the The Health Service (Control of Patient Information) Regulations, 2002[128] empowers the Secretary of State for Health to determine certain aspects of medical confidentiality regulations if it is "in the interests of improving patient care," under advice from the Confidentiality Advisory Group (CAG), which provides legal counsel on uses of healthcare data.

2. USA

The White House Office of Science and Technology Policy released its report on AI, entitled 'Preparing for the Future of Artificial Intelligence' in 2016[129]. The report emphasises the importance of innovation and the ways in which commercially developed AI can be leveraged to tackle social issues and drive innovation and economic growth. Accordingly, the report proposes a light-touch approach to AI regulation, wherein the government should attempt to fit AI into already existing regulatory schemes wherever possible. The report also highlights the importance of research in the field of AI in order to ensure that AI is accountable, transparent, and consistent with human values, and calls about researchers to collaborate with the government and industry to enable the emergence of new industries and drive workforce development.

The US Food and Drug Administration (FDA) issued a number of guidelines in 2016 to encourage the development of, and regulate, medical devices that depend on AI and machine learning. The first guideline deals with general wellness devices, which will not be regulated as medical devices as they are low risk.[130] The second guideline permits the use of real-world evidence, i.e., "evidence derived from aggregation and analysis of real-world data elements" apart from traditional clinical trials, in advocating for devices that have already received approval in one area to receive FDA approval for usage in other areas.[131] The third guideline addresses the adaptive design of guidelines that support the FDA approval of new medical devices[132], allowing new devices to reach patients quicker. The FDA has also released a guidance[133] for manufacturers to maintain the security of devices that are connected to the internet. Its recommendations include continually monitoring for cybersecurity vulnerabilities, creating a program to mitigate potential risks, and working with researchers to identify and tackle issues they can be exploited.

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128 The Health Service (Control of Patient Information) Regulations 2002, Retrieved January 5, 2018, from **http://www.legislation.gov.uk/uksi/2002/1438/pdfs/uksi_20021438_en.pdf**

129 *Executive Office of the President, National Science and Technology Council, Committee on Technology*. (2016). Preparing for the future of Artificial Intelligence. Retrieved January 5, 2018, from **https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf**

130 U.S. Department of Health and Human Services Food and Drug Administration (2016, July 29) General Wellness: Policy for Low Risk Devices. Guidance for Industry and Food and Drug Administration Staff, Retrieved January 5, 2018, from **https://www.fda.gov/ucm/groups/fdagov-public/@fdagov-meddev-gen/documents/document/ucm429674.pdf**

131 U.S. Department of Health and Human Services Food and Drug Administration (2017, August 31) Use of Real-World Evidence to Support Regulatory Decision-Making for Medical Devices. Guidance for Industry and Food and Drug Administration Staff, Retrieved January 5, 2018, from **https://www.fda.gov/ucm/groups/fdagov-public/@fdagov-meddev-gen/documents/document/ucm513027.pdf**

132 U.S. Department of Health and Human Services Food and Drug Administration (2016, July 27) Adaptive Designs for Medical Device Clinical Studies. Guidance for Industry and Food and Drug Administration Staff, Retrieved January 5, 2018, from **https://www.fda.gov/ucm/groups/fdagov-public/@fdagov-meddev-gen/documents/document/ucm446729.pdf**

133 U.S. Department of Health and Human Services Food and Drug Administration (2016, December 28) Postmarket Management of Cybersecurity in Medical Devices. Guidance for Industry and Food and Drug Administration Staff, Retrieved January 5, 2018, from **https://www.fda.gov/downloads/medicaldevices/deviceregulationandguidance/guidancedocuments/ucm482022.pdf**

In 2017, the FDA published a guidance for FDA staff on Software as a Medical Device (SaMD)[134], which seeks to establish clinical evaluation guidelines for SaMD and articulates how to regulate different kinds of software as well as the evidence required for each regulatory category. The FDA is also in the process of developing a digital health unit as part of its Center for Devices and Radiological Health to invest resources in AI.[135]

Challenges to AI in India

Data

"The obstacle to AI implementation in healthcare is not technological but access to data. Research is hampered by difficulties in accessing large medical datasets, for legal or other reasons. It's particularly tough for startups in the field; larger players already have access to such data."[136]

The main data challenges that arise relate to consent for collection, and ensuring that the data is clean and uniform.

Obtaining parental consent for conducting research on children is often easier than obtaining adult consent, since showcasing good intent and fully apprising parents of all details is sufficient to obtain consent. Ensuring clean, digitised data for children is easier and possible from even the pre-birth stage since regular medical contact occurs during antenatal care and later for immunization. However, it is harder for to ensure that data for adults is clean over a longer period of time since contact is typically for illness, and care is often through multiple physicians, unlike single point pediatric wellness care.[137]

India is a data-dense country, and the lack of a robust regulatory regime around the sharing of health data, allows companies easier access to large amounts of data than in other contexts with stringent privacy laws. Yet, the quality of this data can be inconsistent. Though India has adopted an EHR policy, implementation of this policy is not yet harmonized - leading to different interpretations of 'digitizing records (i.e taking snapshots of doctor notes), retention methods and periods, and comprehensive implementation across all hospital data.

India also lacks a formal regulatory regime around anonymization. This has provided companies with more flexibility[138], and has led start up companies to adopt the self-regulatory practice of of anonymising data they receive before using it further. The lack of regulation around data can be a double edged sword, as on the one hand, it is easier for startups to collect data, however the regulatory vacuum causes uncertainty about what future changes might be in store.[139]

Another challenge faced by healthcare startups in India is that though India is a data dense country, India does not have robust open data sets of medical data, thus startups often

134 U.S. Department of Health and Human Services Food and Drug Administration (2017, December 8) Software as a Medical Device (SAMD): Clinical Evaluation. Guidance for Industry and Food and Drug Administration Staff, Retrieved January 5, 2018, from **https://www.fda.gov/downloads/medicaldevices/deviceregulationandguidance/guidancedocuments/ucm524904.pdf**

135 Z. Brennan (2017, May 4), FDA to Create Digital Health Unit, Retrieved January 5, 2018, from **http://raps.org/Regulatory-Focus/News/2017/05/04/27484/FDA-to-Create-Digital-Health-Unit/**

136 Y. LeCun (2016), The Economist: Artificial Intelligence in the Real World. Retrieved January 5, 2018, from **https://www.eiuperspectives.economist.com/sites/default/files/Artificial_intelligence_in_the_real_world_1.pdf**

137 Dr. Bhatnagar, S. (2017, November 24). Personal Interview.

138 R. Vempati, (2018, January 16). Personal Interview.

139 Rangasai, A. (2017, December 15). Personal Interview.

turn to the publicly available datasets that are available in the US and Europe. Yet, this is problematic because the demography represented in the data set is significantly different resulting in the development of solutions that are trained to a specific demographic, and thus need to be re-trained on Indian data. Although AI is technology agnostic, in the cases of drug discovery and genomics the use of demographically different training data is not ideal. For example, in the case of Prostate Specific Antigen (a test for prostate cancer) for the US population, the same parameters would not be viable for the Indian population. A possible solution to strengthen access to medical data for developers in India would be the regulated open data approach. This would involve establishing a body that is responsible for collecting, coordinating and de identifying data from hospitals and relevant government entities, which is then propagated publicly to any relevant end user.[140]

Startups in the field also face issues of data residency and security due to legal barriers relating to the flow of data that prevent people outside the country from accessing it. Since most data exists in the cloud, it has no territorial boundaries; however, data protection laws prevent interoperability. This has made startups wary of the cost and consequences of dealing with medical data. The EU has laid down strict compliance parameters regarding data, which has actually stifled innovation.[141]

Design

Industry professionals have pointed out the need for standard design guidelines for future AI systems - something that is currently lacking in India.[142] Clear design standards can help to provide frameworks to ensure privacy, security, quality, and accuracy of AI solutions and can address questions of ethics and trust. Some design guidelines presently being followed independently by industry professionals in India include: "*1. Do no harm - ensuring that the collection of data does not cause any harm 2. Choice of sharing/ Consent - need for a much better structure regarding it 3. Burden of compliance on data collecting authority - the person collecting the data has more power than the one providing the data, as the authority has greater power to manipulate the data 4 4. Trust the doctor - the doctor should be the final decision maker 5. A modification of 'do not harm principle' in the form of certain parameters that the system should not cross (such as not giving diagnosis and the not substituting the doctor) 6. Abstinence from the use of information that can identify a person 7. Promotion of human to human interaction - there should be human involved in the final decision making.*"[143]

Development

India's weak IP regime, which allows patents to be taken over and utilised to make cheaper generic drugs, means that most pharma companies do not engage in R&D work in India and outsource it to contract research organisations.[144] The lack of robust medical open data sets in India can also hinder the development of AI, as developers must rely on data sets from other countries for their prototypes. Though the Government of India has created a number of incentives for the domestic production of medical devices, drugs etc.[145] - it is unclear if AI technologies and companies benefit from these incentives.

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140 Rangasai, A. (2017, December 15). Personal Interview.

141 S. Mohandas, Centre for Internet and Society (2017, December 16). AI and Healthcare in India: Looking Forward, Retrieved January 5, 2018, from **https://cis-india.org/internet-governance/blog/ai-and-healthcare-in-india-looking-forward**.

142 S. Mohandas, Centre for Internet and Society (2017, December 16). AI and Healthcare in India: Looking Forward, Retrieved January 5, 2018, from **https://cis-india.org/internet-governance/blog/ai-and-healthcare-in-india-looking-forward**.

143 S. Mohandas, Centre for Internet and Society (2017, December 16). AI and Healthcare in India: Looking Forward, Retrieved January 5, 2018, from **https://cis-india.org/internet-governance/blog/ai-and-healthcare-in-india-looking-forward**.

144 Rangasai, A. (2017, December 15). Personal Interview.

145 IBEF Healthcare (2017, November), Retrieved January 5, 2018, from **https://www.ibef.org/download/Healthcare-November-2017.pdf**

Implementation and Adoption

There are a number of challenges to the implementation and adoption of AI in India. Some of these include:

- **Regulatory Authority**: At present, India lacks a Regulating Authority for AI in healthcare. Possible options include the Medical Council of India (/National Medical Commission), the Drug Controller General of India, or a new entity established specifically for this area. A possible alternative could be empowering the MCI to oversee the medical aspects, and a regulator under the Data Protection Bill to oversee issues relating to data. There is also a regulatory gap around medical devices, which has sought to be addressed by the recent Indian Medical Devices Rules, 2017.
- **Appropriate certification mechanism**: One of the biggest issues with the adoption of AI in healthcare in India is acceptability of results, which include direct results arrived at using AI technologies as well as opinions provided by medical practitioners that are influenced/aided by AI technologies. Start-ups in the field often find that they are asked to show proof of a clinical trial when presenting their products to doctors and hospitals, yet clinical trials are expensive, time consuming and inappropriate forms of certification for medical devices and digital health platforms. Startups also face difficulty in conducting clinical trials and as there is lack of a clear regulation to adhere to. They believe that while clinical trials are a necessity with respect to drugs, the process often results in obsolescence of the technology by the time it is approved in the context of AI. Yet, medical practitioners are less trusting towards startups who do not have approval from a national or international authority. A possible and partial solution suggested by these startups is to enable doctors to partner with them to conduct clinical trials together.[146]
- **Infrastructure**: Though India is working to develop and improve national infrastructure[147] necessary for AI to take off in the country remains ignored by policy makers. Cloud-computing infrastructure, for example, is mostly concentrated in servers outside India. Delays in investing in native infrastructure have resulted in many Indian start-ups incorporating themselves outside India due to easier access to infrastructure and technology.[148]
- **Investment**: Investment, though growing, in health related AI in India appears to be currently limited and research is under-funded and explored, especially by the government.[149]
- **Information Asymmetries and Perceptions**: AI-based healthcare solutions often face the issue of information asymmetry between the doctors who use the system and the coders who built it.[150] This may result in hesitation in adopting the software. Furthermore, the perception of AI technologies can be a direct causative factor on how effectively they can be used in treatment. This needs to be researched more, especially in the context of developing countries like India, where the penetration and understanding of technologies are significantly different than in the developed world.[151]

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146 S. Mohandas, Centre for Internet and Society (2017, December 16). AI and Healthcare in India: Looking Forward, Retrieved January 5, 2018, from **https://cis-india.org/internet-governance/blog/ai-and-healthcare-in-india-looking-forward**.

147 For example, the Government of India has launched Megh Raj See: **https://cloud.gov.in/**

148 S. Vempati. India and the Artificial Intelligence Revolution. Retrieved January 19th 2018 from **http://carnegieendowment.org/files/CP283_Vempati_final.pdf**

149 Ibid.

150 S. Mohandas, Centre for Internet and Society (2017, December 16). AI and Healthcare in India: Looking Forward, Retrieved January 5, 2018, from **https://cis-india.org/internet-governance/blog/ai-and-healthcare-in-india-looking-forward**.

151 Dr. Agrawal, A. (2017, November 24). Personal Interview.

Recommendations and Way Forward

The government has formulated a seven-point strategy as a framework for the adoption of AI in India. This includes developing methods for human machine interactions; ensuring safety and security of AI systems, creating a competent workforce in line with AI and R&D needs, understanding and addressing the ethical, legal and societal implications of AI, and measuring and evaluating AI technologies through standards and benchmarks, among others.[152]

India can learn from the approaches of the UK and the USA in encouraging the use of AI by also focussing on:

- **Formulating a Multi-Stakeholder Plan for AI in India**: India has already set up an AI Task Force to come up with recommendations for adoption of AI for economic growth. Like China, which has laid down targets for the development of AI in phases[153], India must also prioritise similar clear milestones and bring in stakeholders from all relevant sectors - including health care professionals and developers working on AI and health solutions. Working together with industry, academia and civil society to formulate guidelines will allow the parties involved to solve the broad and sector specific technical and ethical questions raised by AI more comprehensively and ensure that the technologies deployed align to the national plan.[154]
- **Enabling Access to Data**: By encouraging an Open Data system and ensuring that this data meets the standards set in terms of interoperability, privacy and safety.
  The present use cases of healthcare AI in India tend to be very narrow in their focus. However, AI can potentially have significant implications for macro-level, public health considerations. For example, using AI technology to analyse the multitude of factors (including social and geographic) that could be responsible for pre-term births can result in new insights that allow for more targeted measures to minimise the likelihood of future occurrences.[155]
  However, the biggest hindrance in implementing this is collection of relevant data in a form that is suitable used for AI analysis. Even trial studies require a vast array of data (such as ultrasound scans, clinical data including prescriptions, biological data such as blood tests, etc.) that must then be digitised. In addition, the quality and uniformity of this digitised data must be ensured, which is difficult to achieve manually.
- **Encouraging AI research and development**: Enabling medical colleges to develop centres devoted to research on Artificial Intelligence, and facilitate the exchange of knowledge between academic centres across countries. This can be achieved by collaborations between the government and large companies to promote accessibility and encourage innovation through greater R&D spending. The Government of Karnataka, for instance, is collaborating with NASSCOM to set up a Centre of Excellence for Data Science and Artificial Intelligence (CoE-DS&AI) on a public-private partnership model to "accelerate the ecosystem in Karnataka by providing the impetus for the development of data

152 P. Ray, and S. Malhotra (2017, October 20), Govt sets up expert group for suggestions on artificial intelligence policy, Retrieved January 5, 2018, from **http://www.hindustantimes.com/india-news/govt-sets-up-expert-group-for-suggestions-on-artificial-intelligence-policy/story-R4VnrCufgm7xhh1fVlz9IL.html**

153 Xinhua (2017, July 22), AI development plan shows China's vision, Retrieved January 5, 2018, from **http://www.chinadaily.com.cn/bizchina/tech/2017-07/22/content_30210432.htm**

154 Accelerating India's Economic Growth With Artificial Intelligence, Accenture (2017), Retrieved January 5, 2018, from **https://www.accenture.com/t20171220T030619Z__w__/in-en/_acnmedia/PDF-68/Accenture-ReWire-For-Growth-POV-19-12-Final.pdf**

155 Dr. Agrawal, A. (2017, November 24). Personal Interview.

science and artificial intelligence across the country."[156] Similar centres could be incubated in hospitals and medical colleges in India.

- **Pushing for adoption of AI by businesses and the public sector**: Encouraging companies to invest in AI by providing support and incentives, and encouraging the public sector to adopt AI to improve its services. A mix of models in development financing such as IRR top up can be implemented to drive deployment.[157] Public private partnerships are key in addressing the lack of primary health facilities and care in rural areas.[158] These partnerships must be carried out under a clear framework that ensures transparency and accountability of these processes.
- **Equipping existing and future labour forces with the skill sets to successfully adopt AI**: Medical colleges and other educational institutions should provide opportunities for students to skill themselves to adapt to adoption of AI in healthcare, and also push for academic programmes around AI. It is also important to introduce computing technologies such as AI in medical schools in order to equip doctors to adopt the technical skill sets and ethics required to use integrate AI in their practices. Similarly, IT institutes could include courses on ethics, privacy, accountability etc. to equip engineers and developers with an understanding of the questions surrounding the technology and services they are developing.
- **Setting up a dedicated regulatory framework to oversee AI in India**: At present there is no regulatory oversight in this area, and there are fears that over-regulation could lead to a stifling of innovation. This calls for a national-level regulatory agency that oversees developments in AI in addition to formulating a framework that ensures transparency and accountability of AI systems while promoting and enabling innovation.
- **Design standards and appropriate certification system for health systems driven by AI**: As noted in this report, proof of a clinical trial appears to be the most common certification system asked for by hospitals and other practitioners when considering an AI solution. Yet clinical trials are not tailored for AI technologies and are cost and time intensive. An appropriate certification system is needed to qualify the security and quality of health systems driven by AI. Such a system can incentivise developers to meet needed standards and can work to build trust amongst health practitioners and patients.

  Design standards are also needed to encourage the development of 'responsible AI' Guiding principles to encourage "responsible AI", could include the following [159]:

  1. **Transparency (operations visible to user)**
  2. **Explainability (process followed reaching a decision can be traced)**
  3. **Scrutability (ability to be comprehended)**
  4. **Credibility (outcomes are acceptable)**
  5. **Auditability (efficiency can be easily measured)**
  6. **Reliability (AI systems perform as intended)**
  7. **Recoverability (manual control can be assumed if required)**

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156 NASSCOM (2017, November 16), Government Of Karnataka And Nasscom Partner To Launch Centre Of Excellence For Data Science And Artificial Intelligence, Retrieved January 5, 2018, from **http://www.nasscom.in/sites/default/files/media_pdf/government-of-karnataka-and-nasscom.pdf**

157 R. Vempati, (2018, January 16). Personal Interview

158 A. Kajekar, Supercharging the Indian healthcare industry with Artificial Intelligence (2017, May 24). Retrieved January 5, 2018, from **https://health.economictimes.indiatimes.com/news/industry/supercharging-the-indian-healthcare-industry-with-artificial-intelligence-ashu-kajekar/58818481**

159 PWC (2017, March), Artificial Intelligence and Robotics – 2017 Leveraging artificial intelligence and robotics for sustainable growth, Retrieved January 5, 2018, from **https://www.pwc.in/assets/pdfs/publications/2017/artificial-intelligence-and-robotics-2017.pdf**

- **Regulatory and data sandbox for the health sector:** Regulatory and data sandboxes have been promoted as tools for enabling innovation while protecting privacy, security etc. Data sandboxes allow companies access to large anonymized data sets under controlled circumstances. A regulatory sandbox is a controlled environment with relaxed regulations that allow the product to be tested thoroughly before it is launched to the public. By providing certification and safe spaces for testing, the government will encourage innovation in this sphere. This system has already been adopted in Japan where there are AI specific regulatory sandboxes to drive society 5.0.[160] Regulatory sandboxes and data sandboxes are policy tools that can be considered for the healthcare sector to enable innovation. A governance structure that deals specifically with healthcare can establish a system of ethical reviews of underlying health data used to feed the AI technology along with data collected during clinical practice in order to ensure that this data is complete, accurate and has integrity.
- **Close monitoring towards harmonized implementation of EHR policy:** India developed a comprehensive EHR policy only in 2016. Comprehensive and harmonized implementation of this policy is key in enabling AI startups developing health solutions access to accurate and usable data sets.
- **Planning for the future**: AI solutions in the healthcare sector are presently limited to augmenting the jobs of doctors. Going forward, policy makers, developers, and practitioners need to consider a future where AI can make decisions for or alongside of doctors as they shape policy, design guidelines, and best practices around use. A starting place for this could be having ethical review committees at the organizational level that weigh the implications of the development and use of AI solutions.
- **Liability Framework:** Predictive AI currently faces limitations in the form of high costs and questions around liability.[161] These can be addressed through understanding the cost vs. quality of care vs. insurability and access.
- **Emphasize Privacy and Security**: Health data is sensitive. AI solutions are contributing to the generation, collection, analysis, and action of this data. AI solutions also allow for a potentially broader range of data to be collected, combined, processed, and used in decision making. For example, a chatbot doctor will record an entire conversation vs. a human doctor making notes during a session. The collection and storage of health related data and the potential for bias to be reproduced through the technology raises privacy and security concerns. A key step towards ensuring privacy and security is for India is to enact and effectively enforce a comprehensive privacy legislation.
- **Continuous monitoring and research into impact of AI on the human**: The impact of the use of AI on humans in highly sensitive and personal situations has not been thoroughly studied. Understanding the impact of AI in situations like health care where the technology can take on a partial role of caregiver will be important in developing appropriate ethical frameworks.

Conclusion

Artificial Intelligence has a range of applications across the healthcare sector. By performing descriptive, predictive and prescriptive functions, AI in healthcare in India is currently augmenting human capacity rather than to replacing human labour altogether. However,

160 The Government of Japan. Drive Innovation and Trade. Retrieved January 5, 2018, from **https://www.japan.go.jp/abenomics/innovation/index.html**

161 Dr. Agrawal, A. (2017, November 24). Personal Interview.

AI-powered applications are accompanied by certain challenges – they require an effective framework of laws to govern privacy and data integrity, while dealing with issues of cultural acceptance, informed consent, liability and explainability.

India presently is in a unique position to be a driver in the AI and healthcare space for national and international companies. With large amounts of data and and a burgeoning startup community, India has the opportunity to address many health care related problems through the use of AI. In its quest for India to join the AI revolution, the government has also undertaken a number of initiatives to drive the adoption of AI across the country. Yet, many barriers still stand in the way of widespread adoption and implementation, arising out of a lack of regulatory clarity on issues of data, design and certification and lack of resilient and ethical data collection and processing systems. A robust open data policy, a comprehensive privacy legislation, greater investment in AI research and development, robust national infrastructure, equipping labour forces with the necessary skills to adopt AI and to be prepared for the changes that AI could bring, and a regulatory framework that ensures transparency and accountability but does not hinder innovation, are some of the measures required for the establishment of a flourishing AI healthcare ecosystem in India.

Annex 1
AI in Healthcare in India Ecosystem Mapping

Government Organisations

Authority	Function/ Relevance
Medical Council of India	Permanent registration/provisional registration of doctors with recognized medical qualifications.
Drug Controller General of India - G.N. Singh	Regulatory control over the import of drugs, approval of new drugs and clinical trials, meetings of Drugs Consultative Committee (DCC) and Drugs Technical Advisory Board (DTAB), approval of certain licences as Central Licence Approving Authority is exercised by the CDSCO hqrs. The DCG could would be the authority approving AI powered devices, solutions, drug discoveries etc.
Department of Biotechnology	Providing grants and conducting research projects in the field of biotechnology. The Departnment of Biotechnology presently provides funding to AI healthcare startups.
ISRO	ISRO Telemedicine programme started in 2001 has been connecting remote/rural/medical college hospitals and Mobile Units through the Indian satellites to major specialty hospitals in cities and towns. DOS/ISRO provides Telemedicine systems software, hardware and communication equipment as well as satellite bandwidth. Technology development, standards, and cost effective systems have been evolved in association with various state governments, NGOs, specialty hospitals and industry. The ISRO could potentially develop standards around the use of AI in the healthcare industry in India.
Nursing Council of India	The Nursing Council of India regulates and develops training policies and programmes in the field of Nursing. The Council could potentially provide training and regulatory control over nurses and paramedics that might be using AI, that need training to use AI devices and systems.
Department of Science and Technology	Promotes Innovation, research and projects as well as funding for Science and technology. It is also the Nodal Department for National Policy on Data Sharing and Accessibility (NPDSA). The DST could potentially enable and standardize access to national medical data and could provide funding to companies developing AI and health solutions.
Ministry of Health and Family Welfare	The Ministry of Health and Family Welfare is in charge of the National Health Portal and online registration system. The Ministry could play a key role in integrating and incentivising the use of AI by practioners across the country.
Artificial Intelligence Task Force	The Artificial Intelligence Task Force was created to provide a policy and legal framework to accelerate deployment of AI technologies and to allow a systemic capability to support the goal of India becoming one of the leaders of AI-rich economies. The task force can explore the challenges of AI in health in India as well as define best practices towards fair, ethical, and responsible design and use of the technology.
National eHealth Authority (NeHA)	The goal of NeHA is the attainment of high quality of health services for all Indians through the cost-effective and secure use of information and communication technologies in health and health-related fields. It aims is to map out vision, strategy and adoption time plans, with timeframes, priorities, and road-map in respect of eHealth adoption by all stakeholders, both public and private providers, large scale hospitals and stand-alone clinics. The eHealth Authority could potentially promote, establish best practices, and otherwise develop regulation around the use of AI in health services in India.
National Cancer Research Institute	The National Cancer Research Institute is a leader in Cancer Research and also holds a repository of data on cancer patients in India. The Institute could promote research into diagnosis and technologies for diagnosis that leverage AI.
Government of Telangana	The Government of Telangana has an agreement with Microsoft India to adopt cloud-based analytics care screening program for children.
Ministry of Electronics and Information and Technology	MEITY promotes e-Governance for empowering citizens, promoting the inclusive and sustainable growth of the Electronics, IT & ITeS industries, enhancing India's role in Internet Governance, adopting a multipronged approach that includes development of human resources, promoting R&D and innovation, enhancing efficiency through digital services and ensuring a secure cyberspace. The repository of health data, especially with its network of public hospitals is being put into a central database such as the National Cloud (goo.gl/zKZCcK) with the help of National Informatics Centre, which can be further analysed using machine learning and AI. AI is also planned to be used in medicine distribution.
Policy Group on Artificial Intelligence	The Ministry of Electronics and Information Technology has recently formed a "policy group" to study aspects of AI technology and formulate a policy framework and road map for its adoption. The policy group will consist of representatives from academia as well as NASSCOM for an industry perspective, and will focus on aspects such as privacy, security, liability and skilling the workforce.
United States–India Science & Technology Endowment Fund (USISTEF)	Grants of upto INR 25 million are awarded to bi-national teams of entrepreneurs and innovators who have an innovative product beyond the idea stage with a high societal impact and the potential to commercialise within 2-3 years. Priority areas include biomedical devices and diagnostics, and preventive and curative measures to improve health.
Cognitive Science Research Initiative (CSRI), Department of Science & Technology http://dst.gov.in/sites/default/files/CSRI-AD-2017.pdf	The Cognitive Science Research Initiative was initiated in 2008 as a platform to enable the scientific community to deal with challenges related to cognitive disorders and social issues through the use of psychological tools & batteries, early diagnosis & better therapies, intervention technologies and rehabilitation programmes.The CSRI provides funding to promote cutting edge research around different components of cognitive science, including artificial intelligence. This funding, in the form of individual research grants and Post-Doctoral Fellowships, is available to scientists and academicians working in India.
Biotechnology Ignition Grant Scheme (BIG), Biotechnology Industry Research Assistance Council https://economictimes.indiatimes.com/small-biz/security-tech/technology/indias-big-revolution/articleshow/57200541.cms	The Biotechnology Industry Research Assistance Council (BIRAC) is the nodal funding agency of the Government of India for the biotech industry. BIG was conceptualised by BIRAC in 2012 to address issues faced by startups in the sphere of biotechnology and medical devices due to long gestation periods and market uncertainty. The scheme enables innovators to establish and validate proof of concept (POC) for high-risk, potentially high-impact technological ideas in order to eventually commercialise or implement them. The scheme currently works across the country through five BIG Partners who mentor and monitor the grantees. Grant money amounting to INR 821.96 lakhs (USD $ 1.6m) has been approved for the scheme. Since 2012, BIG has supported more than 200 biotech and healthcare startups.
Centre of Excellence for Data Science and Artificial Intelligence (CoE-DS&AI) http://www.nasscom.in/sites/default/files/media_pdf/government-of-karnataka-and-nasscom.pdf	The Centre will work with partner organisations to expand AI capacity across academia, the government, and businesses by investing technological infrastructure and industry-oriented research, equipping academic institutions to provide education and skill development in DS and AI, encouraging innovation and adoption of data-driven decision making by enterprises and government.

Developers

Company	Type of Company	Sector	Focus Area	Type of AI	AI Solution
Niramai	Domestic	Diagnostics	Oncology	Descriptive	***Niramai*** is an acronym for Non-Invasive Risk Assessment with Machine-learning and Artificial Intelligence. It uses a low-cost device that takes high-resolution thermal images which require no radiation. Artificial intelligence is applied to the images on the cloud to detect breast cancer. Thermalytix is a Niramai cancer screening solution is a thermal analytics-based pain-free breast cancer solution for early stage breast cancer detection. The portable, light and small screening device artificial intelligence led diagnostic platform that uses patented thermal image processing and machine learning algorithms for reliable and accurate breast cancer screening. ***SMILE*** is an interface for users that allows users to upload thermal images and receive a report generated by Thermalytix
Mapmygenome	Domestic	Diagnostics	Genetic counseling and preventative healthcare	Prescriptive	Mapmygenome is a molecular diagnostics company. The ***Genomepatri test*** gives an individual insight into their genome to help people make proactive choices about their health. The company offers personalized health solutions based on genetic tests that help people to get to know about themselves. By combining genetic health profile and health history with genetic counseling, Mapmygenome provides actionable steps for individuals and their physicians towards a healthier life. Mapmygenome is focused on preventive health-care through healthy habits. Mapmygenome as been identified as Entrepreneur India as a pioneer in the field of AI and personal genetics in 2017 [https://www.entrepreneur.com/article/300480]
Innov4Sight	Domestic	Hospitals and Diagnostics	Data analytics in oncology, fertility, pharma, and bio-banking	Predictive	Innov4Sight uses a technology agnostic integrated healthcare ecosystem' that will significantly impact 'Clinical Outcomes' with a focus on Oncology & Fertility. The companies products include: ***ParSight -*** combines global clinical data with machine learning technology to develop next generation cancer health care. ParSight also reads, mines and analyzes multiple data systems and repositories, accesses complete clinical and patient information and allows the physicians to apply the right information through the use of deep analytical capabilities, Vyabl - a comprehensive platform for those aspiring to have a child by improving reproductive health and increasing the success rate in Assisted Reproductive Technology (ART) procedures. Other solutions include: Medical Simulators, Health IT Suite, and Biologics Regenerative Medicine.
Teleradiology Solutions	Domestic	Telemedicine and diagnostics	e-teaching, teleradiology, telemedicine	Predictive	Teleradiology Solutions uses AI in radiology through a platform that combines advanced technology with the cumulative experience of a large team of radiologists. Teleradiology Solutions has collaborated as a group with Zebra Medical Imaging - a pioneer in Machine Learning and Artificial Intelligence.[https://www.businesswire.com/news/home/20170704005396/en/Zebra-Medical-Vision-Artificial-Intelligence-Deployment-Scale]
Microsoft India	International	Diagnostics	Ophthalmology	Prescriptive	Microsoft India is partnering with the Government of Telangana to provide healthcare for children with eye problems by screening for eye issues and preventing 'avoidable' blindness with its AI platform MINE. [https://news.microsoft.com/en-in/government-telangana-adopts-microsoft-cloud-becomes-first-state-use-artificial-intelligence-eye-care-screening-children/]
IBM	International	Diagnostics	Oncology	Prescriptive	IBM has developed an AI platform that can be used in oncology. ***Watson for Oncology*** provides Cognitive assistance, analyzes the meaning and context of structured and unstructured data coming from a variety of inputs to help doctors in the diagnosis and treatment of cancer. Watson for Oncology is being adopted in Manipal Hospital in India.
Google	International	Diagnostics	Ophthalmology	Prescriptive	Google, in conjunction with Aravind Eye Care Systems, has trained its image recognition algorithms to detect signs of diabetic- related eye problems as well as a human doctor, which could lead to timely intervention and prevent blindness. With AI and Google's machine learning algorithm, doctors will be able to grade diabetic retinopathy to a certain level of identification, mainly for screening.
SigTuple	Domestic	Telemedicine	Healthcare Management and Screening	Predictive	SigTuple offers a number of solutions that leverage AI. ***Shonit™*** is a complete peripheral blood smear analyser solution which automates the routine tasks like differential counts. Additionally, it provides a screening solution for various parasitic infections like malaria and disorders like anaemia; Manthana was created, from ground-up, to be a continuously improving, automatically upgrading platform which enables digitisation, management and analysis of visual medical data. SigTuple aims at training various kinds of AI models on the platform in order to provide an insightful and interactive report to medical specialists.
BioXcel Therapeutics, Inc.	Domestic	Pharmaceutical	Pharmacology	Predictive	BioXcel Therapeutics, Inc. is a clinical stage biopharmaceutical company that uses the application of artificial intelligence and big data analytics integrated with drug development expertise. They use ***EvolverAI*** to unearth hidden relationships between diseases, molecular targets and drugs to identify novel therapeutics and re-innovate existing drugs. They also use ***PharmGPS®*** to project the future performance trajectories of drugs in development.
Tricog Health Services PVT. LTD	Domestic	Diagnostics	Cardiology	Descriptive	Tricog's product Insta ECG sources ECG machines from General Electric Healthcare and has built its own sensory device, which is fitted on the machines. These devices are given to general physicians, clinics and nursing homes on a subscription basis. Through the Internet, this device sends the ECG or recorded heart movement to a set of algorithms, which then generates a report. It reduces the time taken to diagnose a potential heart disease/attack from six hours to a few minutes
Philips	International	Diagnostics	Obstetrics	Descriptive	***Philips Mobile Obstetrics Monitoring*** (MOM) software solution uses an AI tool that takes into consideration various parameters from the pregnant woman's obstetric history, antenatal examination, ultrasound/blood investigations and comes up with a pregnancy risk score and risk level. The output of the algorithm is to classify a pregnancy as a low, medium or a high-risk pregnancy. Based on this classification the caregivers can then take critical decisions like referring all high-risk pregnancies to a larger hospital or a specialist.
Aindra	Domestic	Diagnostics	Oncology	Descriptive	Aindra seeks develop innovative devices at an affordable cost to address, their product CervAstra seeks to provide women access to cervical cancer screening with its expertise in artificial intelligence.

Developers

Company	Type of Company	Sector	Focus Area	Type of AI	AI Solution
Advenio Technosys	Domestic	Diagnostics	Radiology	Descriptive	Advenio is a team of technology led social entrepreneurs focused on technology equity in critical sectors, specifically in equitable low-cost healthcare solutions. Advenio uses the ***CADx*** solution in radiology for diagnosis of diseases and infections in X-ray images. The CADx system primarily detects TB from CXR (Chest X-Ray) - on a hardware neutral plug-in. CADx in ultrasonography involves diagnosis of acute infections and diseases from ultrasound images.
Ten3T	Domestic	Diagnostics	Cardiology	Predictive	Ten3T uses AI to build a sophisticated self enclosed, real time monitoring device - ***Cicer*** which sits as a triangular patch on the patient's chest. Data is transmitted in realtime to the cardiologist, with algorithms then looking for indications of cardiac problems- both immediate and long-term
Qure. Ai	Domestic	Diagnostics	Imaging	Prescriptive	Qure.Ai uses deep learning technology to help diagnose disease and recommend personalized treatment plans from health care image. Qure.Ai. offers the following solutions: Head CT scan Emergency Care Diagnostic Aid, Brain Region Quantification, Brain Tumor Quantification, Chest X Ray Screening and Automated Reporting, Lung Nodules, idiopathic Pulmonary Fibrosis, Abdominal Visceral and Subcutaneous Fat Quantification, and Knee Cartilage Segmentation
QorQL	Domestic	Telemedicine	Healthcare management	Predictive	QorQL has developed ***Qcare*** - a set of products for health providers to better manage the health of their patients. The Qcare solution increases a doctor's productivity, care quality and significantly improves the patient experience.***Qhealth*** is a consumer app built to give patients direct control of their health. The product helps patients during the entire illness cycle to engage with clinicians, stay connected and self-manage their care better, easing as much pain as possible.
Touchkin	Domestic	Diagnostics	Mental Health	Predictive	Touchkin has developed the chatbot "***Wysa***", that uses smartphone sensors to help mental health patients in need. Wysa's machine learning platform collects data from mobile phones and sensors, and uses it to identify potential health problems through changes in patterns of communication, activity, and sleep (all of which are tracked via smartphone), and even warns if the user may be at risk for depression.
Predible	Domestic	Diagnostics	Oncology	Descriptive	Predible aims to build machine learning solutions for medical imaging. Its deep learning algorithms target advanced knowledge in cancer treatment powered by a neutral cloud computation platform. It focuses on building radiology solutions to improve accuracy and efficiency of radiologists and physicians.Developed in partnership with leading radiologists, ***PREDIBLELIVER*** enables advanced analysis of multi-phase CT scans to deliver the best quality of care to cancer patients.
IQVIA	International	Telemedicine	Health Analytics	Predictive	IQVIA is committed to providing solutions that enable healthcare companies to innovate with confidence, maximize opportunities and, ultimately, drive healthcare forward. They do this via breakthroughs in insights, technology, analytics and human intelligence that bring the advances in data science together with the possibilities of human science. IQVIA's product ***Ada*** is a persona-based artificial intelligence (AI) platform designed to augment workers' capabilities by making recommendations for next best actions, based on algorithms, machine learning and natural language processing. Ada helps life sciences companies increase productivity, focus on high-value tasks, improve customer engagement and orchestrate across functions.
Healthmir	Domestic	Telemedicine	General health	Predictive	***HealthMir*** is an AI driven health content startup. Healthmir takes care of the complete health cycle of a consumer including connecting individuals with health users like them. It provides a highly personalized content ecosystem with all the information a user needs about diseases, their symptoms, treatment, and diagnosis.
MITRA Biotech	International	Telemedicine	Oncology	Predictive	MITRA Biotech is a global leader in advancing personalized oncology treatment and supporting more effective and efficient cancer drug development. MITRA Biotech has developed ***CANscript™*** which provides essential information to individual cancer patients at crucial points in their treatment path. Canscript uses trained algorithms for generating predictive results that correlate highly with clinical outcomes.
Orbuculum	Domestic	Diagnostics	Predictive healthcare	Predictive	Orbuculum uses artificial intelligence for predicting diseases such as cancer, diabetes,neurological disorders,cardiovascular diseases through genomic data.
VectorDoc	Domestic	Telemedicine	Healthcare management	Predictive	***VectorDoc*** is a healthcare platform developed by YantraMind based on some unique features for cases, referrals and diagnostic decision making through artificial intelligence based solutions.
OnliDoc	Domestic	Telemedicine	General health	Predictive	***OnliDoc*** is an AI driven platform for end-to-end medical diagnosis. AI is used to search for doctors, manage appointments, store medical records and prescriptions. On the diagnosis and treatment side, AI is also used to help in treatment selection, to recommend first actions and prognostic prediction.
Artivatic Data Labs	Domestic	Telemedicine	General health	Descriptive	Artivatic Data Labs provides AI solutions that enable automated and personalized decisions in health insurance, health and wellness, disease detection, genomics and neuroscience, and decision making in diagnosis.
Arya-ai	Domestic	Pharmaceutical and Diagnostics	Drug development	Predictive	Arya ai is using deep learning technology in drug discovery, diagnostics and personalized medicine.
Inayo	Domestic	Telemedicine	Diabetology	Predictive	Inayo is a personal assistant to diabetes patients. At the core of Inayo is Artificial Intelligence and Machine Learning. We have developed more than half million combination of unique diabetes profiles and developed algorithm in consultation with senior diabetologists, nutritionists, diabetes educators, Podiatrist, Ophthalmologists, and Endocrinologists. The core components of the diabetes management program are as follows: • Education and counselling about diabetes. • Self care and lifestyle management. • Medication and diagnostics tests at the convenience of your home. • Expert monitoring to keep track of patient progress. • Performance based financial rewards and recognition.
Graype	Domestic	Telemedicine	Healthcare management	Predictive	Graype uses AI for consolidation of medical reports, and a medical assistance app. Graype has launched two products ***Wink*** - a high quality open source package for Statistics, Natural Language Processing and Machine Learning in NodeJS and ***Decisively***- a means to simply data driven decision making.

Developers

Company	Type of Company	Sector	Focus Area	Type of AI	AI Solution
Bugworks Research	International	Pharmaceutical	Pharmacology	Predictive	Bugworks uses a computational platform where the network is built to copy the behavior of the microbe, especially in infection related situations. The computational software replicates the effort put in the preclinical stage. The software acquires the genomic sequence information and offers enough analysis for the investigating chemist to arrive at relevant conclusions. The prowess of the platform lies in its ability to study interactions that are seemingly disconnected.
Cureskin	Domestic	Diagnostics	Dermatology	Predictive	Cureskin has developed the ***Cureskin app*** that automatically analyses pictures of skin to find skin issues like pimples, acne, dark spots, scars, pigmentation on the face.
Lantern Pharma	International	Pharmaceutical	Pharmacology	Predictive	Lantern Pharma is reinventing the cancer drug development process by tailoring multiple promising precision drug programs to the right cancer patients using advanced genomics and artificial intelligence (AI) with significantly reduced cost and time. Lantern Pharma has developed RADR V 3.0™ – an integrated data analytics, experimental biology and machine learning based platform for patient genetic profiling for drug response prediction.
Netripples	Domestic	Hospitals	Healthcare management	Predictive	Netripples uses AI in its services including data migration and business process outsourcing for Hospitals. The ***Netripples*** range of software has over 250 clients using solutions and applications world wide.
Searchlight Health	Domestic	Telemedicine	Healthcare data analytics	Predictive	Searchlight health has developed a number of solutions that leverage AI. Opportunity Analyzer enables hospitals to understand the status of the market and the performance of the hospital in a highly granular fashion. The solution benchmarks actionable, business-decision oriented insight into key performance indicators for clinical, operational and functional performance, Hospital CRM enables a hospital to strengthen relationships with doctors and patients.The Care Pathway Analyzer searches and evaluates medical case histories based on diagnosis, procedures, demographic data and other relevant clinical information. Prescription Analyzer provides practitioners with detailed insights on drug prescriptions patterns at hospitals in India. It helps in understanding sales trends and correlation of when and why your drugs are prescribed. It also helps in understanding disease propensity and factors that drive drug demand to identify and estimate potential market opportunities. Policy Builder combines nationwide hospital data with powerful modelling tools to help you identify new product and segment opportunities. It also clearly models claims payout for the policies that you define and lets you iteratively arrive at the best balance between price and potential market opportunity. Corporate Policy Pricer aggregates the estimated morbidity of each individual in the insured pool of your prospective corporate client and accurately determines the future payout. Based on the power of nationwide repository of health data, the solution helps you manage your margins while improving the market share.
DocsAPP	Domestic	Telemedicine	General Health	Predictive	***DocsApp*** combines artificial intelligence and medical science to provide effective solutions to doctors and connects patients with doctors, allows patients to chat with doctors, and provides consultation to patients
FEDO	Domestic	Telemedicine	Lifestyle disease	Predictive	***FEDO Self Learning Platform*** harnesses the power of AI to predict individual's risks for lifestyle diseases. The solution seeks to increase awareness of propensity for disease, informative health insights at an individual and population level
Practo	Domestic	Telemedicine	General Health	Predictive	***Practo*** is an online healthcare platform that lets consumers search and make appointments with health care providers. The company has plans to integrate AI into its platform and sees AI as playing a key role in the future of healthcare and how doctors treat patients. The company uses algorithms to help patients search for doctors and health care.
iCliniq	Domestic	Telemedicine	General Health	Descriptive	***iCliniq*** is an online doctor consultation platform where users can get medical advice from doctors. They provide various channels to contact doctors such as posting a health query or booking a slot for real time face-to-face consultation over HD video and phone (it will be a private/secure call back). One can use the service to consult with highly qualified physicians at the comfort of the home. iCliniq.com said it is in talks with private equity investors to raise around Rs 25 crore to fund an acquisition and invest in artificial intelligence technology to help doctors answer patients' queries faster.
Curill	Domestic	Telemedicine	Customer Service (Chatbot)	Prescriptive	Curill has developed solutions named ***Qdoc*** powered by AI technology that mimics a doctor i.e. asks intelligent questions, understands test reports and suggests further investigations.
TerraBlue	Domestic	Medical Equipment and Supplies	Neurological disorder	Predictive	TerraBlue's product ***TJay*** is currently designed for the early detection and management of epilepsy. It consists of a wearable device and uses a ML/AI-based software solution that provides predictions before the onset of epilepsy.
Mfine	Domestic	Telemedicine	Healthcare Management	Predictive	***Mfine*** has developed a platform that provides a chat window which patients can use to consult doctors from hospitals on the network. The platform also allows for the collection of samples for lab tests and the ordering of medicines online. The platform is enabled through a smart assistant that uses Artificial Intelligence to improve the quality of diagnosis and optimize the doctor's time.
Intuition Systems	Domestic	Telemedicine	Healthcare Manag	Predictive	Intuition's technology platform ***IVEPOS*** has been successfully applied in many technology applications and now it will work with pharmaceutical companies existing proprietary computational resources to advance AI, big data analysis, cloud support and infrastructure for novel drug developments and treatment.
TrueMD	Domestic	Pharmaceutical	Online Pharmacy	Descriptive	***TrueMD*** allows individuals to order medicines to their doorstep and manage their prescriptions. As part of their services, TrueMD offers an A.I chatbot to answer questions consumers might have about their medicines.
Bajaj Allianz General Insurance	Domestic	Health Insurance	Customer Service (Chatbot)	Predictive	***BOING*** is an Artificial Intelligent Chatbot service platform that Bajah Allianz General Insurance recently launched which offers 24/7 customer assistance and instantly responds to customer queries. It helps the customer to register a motor claim, get policy soft copy, check policy status (Motor & Health), check claim status, locate company branch and nearest empanelled hospitals and workshops. These services of the chatbot will be integrated with Amazon Alexa.

Developers

Company	Type of Company	Sector	Focus Area	Type of AI	AI Solution
ICICI Lombard General Insurance	Domestic	Health Insurance	Customer Service (Chatbot)	Predictive	The ***MyRA*** chatbot offers direct interaction for customers/ insurance agents with a virtual assistance robot to seek faster quotes for policy issuance. It has enabled the company to address customer queries on a real-time basis. Using artificial intelligence, the tool has allowed the company to automate the query management process without the need for human intervention. MyRA currently addresses products such as two wheeler insurance as well as fire and burglary insurance for small and medium sized enterprises.

Practitioners

	Type of AI	Relevance	AI Solution and Use
Tata Memorial Hospital	Descriptive	The Tata Memorial Hospital Ethics Committee has established the Data and Safety Monitoring Sub Committee for monitoring the conduct of the institutional trials. The Committee has 15 members and meets on the first Friday of every month.	Provides electronic medical records and data to startups after getting approval from ethics committee
Fortis	Predictive	Multispeciality hospital	Has partnered with Philips and GE Healthcare to launch tele-ICU for patients
Columbia Asia Hospitals	Predictive	Multispeciality hospital	The hospital will be using Cardiotrack's hand-held devices which use a patient's historical ECG data to predict heart condition. The machine processes this ECG data using AI algorithms for cardiac prediction.
Sankara Nethralaya - Chennai	Descriptive	Eye Hospital	Using Google's algorithms and AI technology for detecting referable diabetic retinopathya
Narayana Nethralaya - Bangalore	Descriptive	Eye Hospital	Using Google's algorithms and AI technology for detecting referable diabetic retinopathy
LV Prasad Eye Institute (LVPEI)	Descriptive	Eye foundation	In Partnership with Microsoft to use machine learning to trace the patterns of eye disease
Apollo Hospitals	Descriptive	Multispeciality hospital	Is using Microsoft Azure, Machine Learning, Data Analytics, CRM online and Office 365 to enhance their efficiency and improve patient care
Max Healthcare	Descriptive	Healthcare Institute	Is using Microsoft Azure, Machine Learning, Data Analytics, CRM online and Office 365 to enhance their efficiency and improve patient care
H. N. Reliance Foundation Hospital	Predictive	Healthcare Institute and Research Center	Has online patient services for medical records and booking appointments.
Manipal Hospitals	Predictive	Multispeciality hospital	Using IBM Watson for Oncology
Cyngus Hospitals	Descriptive	Multispeciality hospital	Uses Tricogs services to help in detecting heart disease
Aster CMI Hospitals	Descriptive	Multispeciality hospital	Uses Tricogs services to help in detecting heart disease
RV Metropolis Diagnostic & Healthcare Center Pvt Ltd	Descriptive	Multispeciality hospital	Uses Tricogs services to help in detecting heart disease
Aravind Eye Hospitals	Descriptive	Eye Hospital	Using Google's algorithms and AI technology for detecting referable diabetic retinopathy

Research Community

Name of Researcher or Organization	Name of research paper	Summary of Research Paper
Dr. Anurag Agarwal	Agrawal A, Bhattacharya J, Baranwal N, Bhatla S, Dube S, Sardana V, et al. (2013) Integrating Health Care Delivery and Data Collection in Rural India Using a Rapidly Deployable eHealth Center. PLoS Med 10 (6): e1001468. https://doi.org/10.1371/journal.pmed.1001468	This report was the summation of the learnings, from the setting up of an E-health center in a village in India.The e-health center, was created in cargo containers, with verifiable cloud-based electronic workflow and records, telemedicine capability, and automated online reporting of summarized health data and operational status.
Price Water Coopers India	Report on AI and Robotics in India	The report examined the use of AI in India, in various sectors, as well as the global policy initiatives and the path ahead.
FICCI Health Services Committee	The Re-engineering Indian health care Report	This joint study by FICCI and EY evaluates various aspects the changing face of the especially with respect to technology and the role that the government as well as the private sector will play in bringing in this transformation, while keeping the patient as the prime focus.
Ernst and Young	The Re-engineering Indian health care Report	This joint study by FICCI and EY evaluates various aspects the changing face of the especially with respect to technology and the role that the government as well as the private sector will play in bringing in this transformation, while keeping the patient as the prime focus.
Confederation of Indian Industries	Report on Medical Technology in India	This report was drafted to enable the domestic and international Medical Technology companies to understand the emerging business opportunities and the healthcare ecosystem in India.
Deloitte	Report on Medical Technology in India	This report was drafted to enable the domestic and international Medical Technology companies to understand the emerging business opportunities and the healthcare ecosystem in India.
B.V.B. College of Engineering and Technology, Hubli	Patil, P., & Mohsin, S. (2013). Fuzzy Logic based Health Care System using Wireless Body Area Network. system, 80(12).	The paper discusses the technical details concerning 'Wireless Sensor Networks' and its broad list of potnetial uses for various interest groups. It goes into the details of how WSN systems constantly track and upload data to a remote user. On this point, the paper discusses 'Fuzzy Logic Theory', a concept previously used for industrial purposes. The paper argues that fuzzy logic programs can be harnessed to allow for better analysis of data obtained from WSN's which can in turn, also help make conclusions drawn from such data, easily understandable.
Tontadarya College of Engineering, Gadag	Patil, P., & Mohsin, S. (2013). Fuzzy Logic based Health Care System using Wireless Body Area Network. system, 80(12).	The paper discusses the technical details concerning 'Wireless Sensor Networks' and its broad list of potnetial uses for various interest groups. It goes into the details of how WSN systems constantly track and upload data to a remote user. On this point, the paper discusses 'Fuzzy Logic Theory', a concept previously used for industrial purposes. The paper argues that fuzzy logic programs can be harnessed to allow for better analysis of data obtained from WSN's which can in turn, also help make conclusions drawn from such data, easily understandable.
Jadavpur University	Bhunia, S. S., Dhar, S. K., & Mukherjee, N. iHealth: A Fuzzy approach for provisioning Intelligent Health-care system in Smart City.http://ieeexplore.ieee.org/document/6962169/	This paper seeks to suggest a solution for the scarcity of doctors. The system proposed would be an IoT based health monitor that uses fuzzy inference rules to providing round the clock health services as well as reduce the burden on the doctor by letting him know which patients need his immediate attention.
Bannari Amman Institute of Technology, Coimbatore	Kumar, S. S., & Kumar, K. A. (2013). Neural Networks In Medical And Healthcare. International Journal of Innovative Research and Development, 2(8).http://www.ijird.com/index.php/ijird/article/view/36398	This paper seeks to explain Neural Networks and how it can be used in healthcare, such as in Cardiology, Intensive Care, Oncology, to name a few.
Dr. SNS Rajalakshmi College Of Arts And Science, Coimbatore	Kumar, S. S., & Kumar, K. A. (2013). Neural Networks In Medical And Healthcare. International Journal of Innovative Research and Development, 2(8).http://www.ijird.com/index.php/ijird/article/view/36398	This paper seeks to explain Neural Networks and how it can be used in healthcare, such as in Cardiology, Intensive Care, Oncology, to name a few.
Department of Computer Science & Engg., University Visveswaraya College of Engineering,	AnandaKumar, K., & Punithavalli, D. M. (2011). Efficient cancer classification using fast adaptive neuro-fuzzy inference system (FANFIS) based on statistical techniques. IJACSA) International Journal of Advanced Computer Science and Applications, Special Issue on Artificial Intelligence, 132-137.http://thesai.org/Publications/ViewPaper?Volume=1&Issue=3&Code=SpecialIssue&SerialNo=21	This paper proposes a system of cancer classification using training data sets and then classifying the genes selected and then further testing them using Fast Adaptive Neuro-Fuzzy Inference System (FANFIS) in which the training is performed using Modified Levenberg-Marquardt algorithm.
Department of Computer Science & Engg., SJB Institute of Technology	AnandaKumar, K., & Punithavalli, D. M. (2011). Efficient cancer classification using fast adaptive neuro-fuzzy inference system (FANFIS) based on statistical techniques. IJACSA) International Journal of Advanced Computer Science and Applications, Special Issue on Artificial Intelligence, 132-137.https://thesai.org/Downloads/SpecialIssueNo3/Paper%2021-Efficient%20Cancer%20Classification%20using%20Fast%20Adaptive%20Neuro-Fuzzy%20Inference%20System%20(FANFIS)%20based%20on%20Statistical%20Techniques.pdf	This paper proposes a system of cancer classification using training data sets and then classifying the genes selected and then further testing them using Fast Adaptive Neuro-Fuzzy Inference System (FANFIS) in which the training is performed using Modified Levenberg-Marquardt algorithm.

Department of Computer Science, DAV College, Jalandhar, India.	A Multi-agent Medical System for Indian Rural Infant and Child Care. Vijay Kumar Mago and M. Syamala Devi https://www.aaai.org/Papers/IJCAI/2007/IJCAI07-225.pdf	The paper seeks to provide a solution to Indian rural child healthcare problems using a multi agent system. This system is concerned with intelligent connected systems that interact and decide for themselves what they should do in order to achieve the design objectives.
University Institute of Technology Burdwan	M. Syamala Devi, Vijay Mago, (2005) "Multi-agent model for Indian rural health care", Leadership in Health Services, Vol. 18 Issue: 4, pp. 1-11,https://www.ncbi.nlm.nih.gov/pubmed/16335616	The objective of this paper is to present a model that uses multi-agent system (MAS) technology to assist doctors based at rural areas to receive timely expert opinions from specialist doctors working in medical institutions. A MAS is a software entity wherein agent metaphor is used to represent human-like intelligence and behavior.
	Gupta, S., & Pujari, S. A multi-agent system (MAS) based scheme for health care and medical diagnosis system. In 2009 International Conference on Intelligent Agent&Multi-Agent Systems http://ieeexplore.ieee.org/document/5228086/	In this paper, the authors have attempted to propose an advanced scheme of agent-based health care and medical diagnosis system using the knowledge base and collaborative as well as co-operative intelligent agents residing on a multi-agent platform, which provides a communicative task-sharing environment.
Computer Engg. Dept, MITCOE Pune, India	Gund, M., Andhalkar, S., Patil, D., & Wadhai, V. M. (2011). An intelligent architecture for multi-agent based m-health care system. International Journal, 1-5.https://pdfs.semanticscholar.org/41d0/9d6eb3be4e55f346099d63e8feb042ad6078.pdf	In this paper, multi agent based mobile health monitoring system is proposed which is the combination of a wireless medical sensor module with data mining techniques.

Investors/ Funders

Name	Relevance	Invested in
Kalari Capital		Advenio Technosys.
Sachin and Binny Bansal from Flipkart		SigTuple
Accel Partners		SigTuple, CureFit
Endiya Partners		Looking out to invest on health startups using AI in healthcare
pi ventures		Sigtuple , Niramai, Zenatix, ten3T
YourNest Angel Fund		Arya.ai
VentureNursery		Arya.ai
Ankur Capital		Nirmani
500 Startups		Nirmani
Venture Highway		SigTuple
Mr.Debanjan Mukherjee		SigTuple
Dr. Neerupa Bareja		SigTuple
VH Capital		SigTuple
Kenmark Ventures		Inayo
Zishaan Hayath		Inayo
Villgro Innovations Foundation		Inayo
Department of Biotechnology Government of India		ReIAgent
Sequoia		Practo
Matrix Partners		Practo
Tencent		Practo
CapitalG		Practo
ru-Net		Practo
IDG Ventures		1MG Technologies
Omidyar Network		1MG Technologies
HBM Healthcare		1MG Technologies
Kae Capital		1MG Technologies
Maverick Capital		NetMeds
Tanncam Investment Company		NetMeds
Axilor Ventures		Nirmani
Bill and Melinda Gates Foundation		Advenio

Conferences and Exhibitions

Conference name	Organizer	Date	Place
Smart Healthcare Summit 2016		24th-25th November, 2017	Bangalore
Artificial Intelligence for Next Generation HR Leaders	Bombay Chamber of Commerce	28th July , 2017	Mumbai
AI & Deep Learning Transforming Enterprise Decision Making	NASSCOM	22nd-23rd June, 2017	Hyderabad
IOT India Congress	Institute of Engineering and technology	14-15, September 2017	Bangalore
Future of Healthcare'	Confederation of Indian Industry (CII)	14, December, 2017	New Delhi
AI and IT Summit	Ministry of Electronics and Technology	18-19 th January 2018	Hyderabad
Smart Healthcare Summit 2018	Smart Tech	1st and 2nd February 2018	Bangalore
Bengaluru Tech Summit	Department of IT and BT Government of Karnataka	16-18th November	Bangalore