Review Article

Use of artificial intelligence in healthcare delivery in India

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Abstract: The growth of artificial intelligence (AI) has seen an exponential growth in India. Recent policy initiatives favouring the acceleration of AI application in Indian healthcare is discussed. This article then captures the range of AI applications in healthcare in India. The AI applications range from those used in early screening or diagnostic space, to those used in treatment and rehabilitation. In the Indian healthcare space innovations that can improve rural healthcare is greatly valued. Several of the start ups featured in this article have sought to apply AI to rural Indian healthcare to address the gaps. With smartphone boom AI enabled reality can be possible. However there are several challenges to scale up use of AI in healthcare delivery in India about which this article concludes with. Currently most of the applications are still at a regional level. Several issues are there to scale up the data level needs to be addressed before AI can truly be a reality for India. Data availability, data pooling, data collection, data sharing, data protection, data privacy are among the multifaceted issued which must be sorted out. Other challenges range from human resource issues to lack of awareness to need to address ethical issues in AI based innovations, to cyber security issues, lack of infrastructure, besides the high cost of investing in AI based innovations. Several policy mechanisms and regulatory frameworks are being brought out to address these challenges via NITI Aayog Towards Responsible #AIforAll. The article concludes on the fact that AI in healthcare can potentially change the landscape if done right.

Keywords: Healthcare; artificial intelligence (AI); India

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Introduction

An individual patient data when aggregated with others across the health system artificial intelligence (AI)'s predictive capabilities are enhanced as its to make better decision making via improved public health surveillance besides producing leaner, quicker and more focussed research and development (1). AI is poised to be an aide for all healthcare professionals as it becomes an integral part of healthcare whether it is to automate patient data documentation or fast tracking image analysis as well as assist with virtual observation, diagnosis, rehabilitation, mental health support and patient outreach (2-4). AI can prove to be an efficient tool for identification of early infections, developing treatment protocols, drugs and vaccine development (5). Whether medical, epidemiological or molecular applications AI in healthcare can help.

Presence of AI in Indian healthcare

Several research studies over the last two years have increasingly brought out the fact that AI technologies have the potential to bridge the gap particularly in rural areas to better access quality healthcare (5-7).

A multitude of stakeholders including Microsoft and Google, have also come together to work on variety of initiatives to build AI infrastructure across India (8,9). They have conducted pilots with hospital chains in India (10).

Indian policy space accelerating use of AI in healthcare delivery

'NITI Aayog' the policy think tank of the Government of India was authorised to formulate the national strategy on AI and other emerging technologies in 2018 (11). NITI Aayog focused on five sectors that are envisioned to benefit the most from AI in solving societal needs of which healthcare is one (11). The motto adopted by NITI Aayog in this venture is 'AI for all' (#AIforAll).

NITI Aayog also seeks to ensure adequate data privacy, security and balancing ethical considerations with the need for innovation (11). The following recommendations are being put in place to accelerate the pace of AI related innovations in healthcare.

- Creating a multistakeholder marketplace—The National Artificial Intelligence Marketplace.

The development stage requiring a multitude of specialized processes. In order to encourage the development of sustainable AI solutions in healthcare it is crucial to address information asymmetry and promote effective collaboration. This may be possible by creating a 'marketplace' which could:

- Enable access to the required AI component, be it data or business models, and services, such as data annotation, and enable rating of these assets;
- Serve as a platform for execution and verification of transactions.

Ensure data today which is being collected at the individual hospital level but not analysed be collected to build the big dataset envisaged to accelerate AI work.

Unraveling new sources of data and facilitating more efficient use of computational and human resources. It is estimated that only 1% of data today is analyzed due to lack of awareness and availability of AI experts. For instance, several medical imaging centers are collecting valuable data; however, these databases are not analysed since AI models cannot be created without computational infrastructure and trained personnel (11). In the presence of a formal marketplace, diagnostic centers would have an incentive to collect these data and provide access to the data in the market with requisite security measures in place.

- Provide an opportunity to address ethical concerns regarding data sharing: creation of a formal marketplace for data transactions would ensure the development of data security measures to prevent misuse of valuable information.

The development of a data protection law in India is currently underway. This, along with the promotion of local innovators and leaders in AI technologies, are crucial steps to ensure that the big data generated in India is used to empower local populations and provide them with services, rather than to exploit them for commercial gains (12).

Partnerships and collaboration

A stratified approach to partnerships is proposed as follows:

- Low transfer: informal interactions such as conferences and social networking;
- Medium mobility: training of industrial employees, internship programs, and academic entrepreneurship;
- High relationships: sharing infrastructure and interorganizational arrangements for pursuing R&D. For instance, a radiologist and computer scientist could work together to develop solutions and enhance knowledge in real time (11).

Promotion of AI in India

The Union Health Ministry has also publicly expressed eagerness to incorporate AI into Indian healthcare. The Union Minister stated that potential of AI in public health was being explored for India. NITI Aayog proposes the creation of 'Big Data' sets (11). This could then be utilised by those entering this space like the Indian AI developers. Department of Biotechnology is also facilitating the implementing of solutions for rapid deployment of AI in healthcare in India (11).

In India health is both a national priority as well as priority for states to deliver on. Several states have taken on the initiate to accelerate AI innovation in healthcare (12-14).

A major hurdle to the adoption and promotion of AI is the lack of awareness with regards to the work being done across the country. The promotion of AI is can be overcome by creating an online portal such as an AI Database for registered people to access and obtain information (11).

Promoting startups

Availability of financial support and adequate infrastructural facilities is important to ensure their participation in AI projects (11).

Accelerating the HR pool in India with skillset to match the AI in healthcare needs

Start of multidisciplinary programmes have been initiated in

several Universities to accelerate the production of human resource skills trained with the right skill set (11).

- PG programme in Medical Science and Technology programme offered by IIT Kharagpur which provides an option for MBBS graduates to enter into engineering for those with an interest in AI;
- AIIMS and IIT Delhi are working on several collaborative projects of AI in healthcare from government/semi government front;
- Centre for AI has been established in JSS Medical College, Mysore, Karnataka;
- Centre of Excellence in AI has been launched in India (www.opengovasia.com). The center of excellence has been developed by the national informatics center to use AI to improve the delivery of government e-services;
- The Hope Foundations—International Institute of Information Technology launched its Centre for of Excellence in Artificial Intelligence at Hinjawadi;
- Narayana Health uses data analytics, and IA to provide affordable healthcare high quality healthcare;
- Health Ministry signs MOU with AI based work solutions in combating TB;
- Amazon Alexa, launch in Pune on Aug 30, 2019, Chandra Kumar—for the first time Amazon team will conduct hands on workshop for developing Alexa assistants;
- TISS and CII—National Conference on AI in Health;
- Chitkara University has been leading with a lot of innovation programmes which it is offering to computer science students with specialisations in different areas of AI like Big data; Artificial intelligence;
- IIIT Delhi is another institute actively working on AI solutions in healthcare.

Classification of AI use in Healthcare in India

There are four broad categories for AI in healthcare (15):

- Descriptive: this is currently the most widely used. It involves quantifying events that have already occurred, and using this data to detect trends and other insights; 'what wellness monitoring or clinical episode happened';
- Diagnostic: why a specific clinical episode or healthcare case had happened;
- Predictive: this uses descriptive data to make predictions about the future, about what healthcare issues are likely to happen;
- Prescriptive: not only detects trends but also suggests possible treatments in public health or more targeted clinical trials in research and development. It seeks to 'prescribe to the relevant actions required to mitigate or eliminate healthcare problems and to exploit specific healthcare trends in improving patient or care outcomes'.

Applications of AI in Indian healthcare

Indian Institute of Technology Bombay incubated a startup Matra Technology which developed a mobile based AI technology Naima which reduces pregnancy risk (16) (https://www.wadhwaniai.org/). Maternal, newborn and child health—smartphone based anthropometry technology which allows frontline health workers to screen for low birth weight babies (17).

In 2016, Niramai Health Analytics (Bangalore), developed a non-invasive, low-cost solution to screen early breast cancer based on mapping body heat embedded with AI technique (18). 'Niramai' is an acronym for Non-Invasive Risk Assessment with Machine-learning and Artificial Intelligence. It can detect tumours five years earlier than mammography or clinical exams based on 'Thermalytix' technology (18,19).

Janitri Innovations focusing on pregnancy healthcare with different innovations like Daksh a paperless labour monitoring system (20). Keyar a non-invasive cardiotocography CTG device that can monitor the heart rate of a baby in the mother's womb and track uterine contractions of pregnant women. This device is portable, non-invasive, and easy to use in rural remote areas (21). The performance of the device when tested against the gold standard CTG machine at St Johns Medical Hospital in Bangalore was equivalent to the gold standard (21).

Predictive AI has shown that for predicting suicide attempts, AI triumphs over human beings (22,23).

Taking family history using chat bots will be great boon in Indian setting because patients usually travel from far off places to city's or town's only to sit and answer questions (24,25). This can be a great time saver. Family history is extremely important in genetics. In India voice bots may overcome several challenges of literacy which chatbots face. Challenge in chatbot development is—how to translate most of it in regional languages that is comprehensible by a lay person; also they have limitation in areas with limited literacy.

AI in screening

AI has been found to be as effective and in some cases, more effective particularly in diagnostics areas like radiology and pathology (11). CARING (Centre for Advanced Research in Imaging, Neuroscience and Genomics) applied AI to imaging as well as the integrative research in the field of neuroscience and genomics and they have taken forward cutting edge scientific and clinical research but also focussed on producing relevant products in collaboration with others (26,27).

AI-based Radiomics project by NITI Aayog in collaboration with Tata Memorial Centre Imaging Biobank (Machine learning and Artificial Intelligence Database and Tumor Radiomics Atlas Project for Cancer unit) is currently underway. There are several other interesting innovations happening with NITI AAYOG (11).

Currently it has been used in medical diagnosis, in psychiatry and for treatment of certain medical ailments (19,20).

Diabetic retinopathy: Remidio Fundus on Phone—portable affordable retinal camera. This AI innovation shifts DR screening to primary care centres (28). Medios AI automated screening of referable DR on the Remidio FOP works offline, and is deployed on camera smartphone. It works with non-mydriatic image and output and provides referral for ophthalmologist and visualization of the detected lesions.

There are AI innovations for Histopathological image analysis as well as TB screening using X-rays (29,30). Wadhwani Institute for AI is also doing tremendous work in this areas as official AI partner for India central tuberculosis division technologies (31).

Medical Devices Based on IOT/IOMT—are uploading and analysing data in real time; used for quarantined self to telemonitoring/teleICU consultation to AI predication from sepsis (32,33). There are AI enabled devices like wheelchairs- sensor for automatic parking of wheelchairs (34), thermometer, weighing scale, ECG (35).

Founded in 2018, Kolkata based medtech startup is building affordable non-invasive AI based solutions for early diagnosis of chronic diseases. This device aims to make the adoption of preventive healthcare approach more feeling accessible for Indians by providing easy affordable diagnostic solutions (36). The startup first product AJO which stands for anemia jaundice and oxygen saturation is a non-invasive IOT enable device that test for anaemia liver and lung related medical problems without any blood work and for less than Rs 1. The user friendly device does not require medical knowledge or expertise to operate once the test is completed the result can be transferred by email or text message in less than 1.5 seconds. The device cleared clinical trials at NRS Medical College Kolkata with high accuracy (36).

Osteoporosis Prediction Models for Patients' Risk Assessment

The aim of this invention ˜Osteoporosis™ is to design the predictive model for early and accurate detection of osteoporosis. In most of the situations patient's age, weight, and gender are taken as the clinical features. It assesses the risk of patient having developed osteoporosis by classifying the patient into at risk or not at risk category (37).

AI in treatment interventions

Kochi based startup founded in March 2017 BAGMO (blood bag monitoring) device addresses lack of blood availability in rural India. It has developed a blood bag monitoring device bag more which monitors temperature of blood bank blood bags during transportation and storage. It improves logistics and communication issues (38,39).

Prantaeis is Bhubaneswar based biotech startup born out of experience of the founder suffering from a pregnancy disorder called pre-eclampsia; this startup develops devices and diagnostic solutions mainly for pregnancy related health care. So far 4 products are there this includes EyeRa for early detection of preeclampsia; ProFoIU to monitor kidney health Salubrious, which provide solution for hidden hunger and Embargo which can detect antibiotics in food products (40).

Waferchips Techno solutions developed in Kollam Kerala is a wearable electrocardiography ECG device called 'Biocalculus' to transfers data to an Android application via Bluetooth if a smartphone is not available. It will store the data up to a month of recording. The device uses AI to generate a clinically actionable report for further diagnosis and treatment (41).

AI in rehabilitation

One of the areas where AI is helping is in the area of rehabilitation. There are several AI based products which are coming out which help in mobility. They include rehabilitative prosthetics, exoskeleton, augmentations, Brain

Computer Interface (BCI) EMG based interface to take inputs from thoughts (42).

AI in times of COVID

AI played an important role in times of COVID (43,44). Various AI applications have been tested for

(I) Early detection and diagnosis of the infection;
(II) Monitoring treatment;
(III) Contact tracing;
(IV) Futuristic projections of cases and mortality;
(V) Development of drugs and vaccines;
(VI) Reducing workload of healthcare workers;
(VII) Prevention of disease.

Challenges to be addressed to scale up use of AI in healthcare delivery in India

The challenges and barriers to the implementation of AI in healthcare in India must be understood to facilitate the scaling up of use of AI in healthcare India (45).

Lack of trained personnel and expertise for AI

Replacement of humans because of AI is another huge worry which affects the support for the adoption of AI in healthcare (46). The lack of AI trained professionals can also be a key barrier to using AI in healthcare (45).

Awareness of AI and quicker deployment of AI innovations

There is a lack of awareness about potential and benefits of AI use in healthcare delivery at level of multiple stakeholders. Neither healthcare owners, healthcare professionals nor patients have much idea about it in India. There is still a lack of understanding of AI and its benefits, among medical professionals particularly among those in leadership positions and the general population (47). Information asymmetry among the stakeholders is another huge challenge (48). Negative media in India of the impact AI will have on jobs has resulted in an increased struggle for start-ups to acquire funding (47).

Ethical issues of AI in healthcare delivery

Inequality concerns in the adoption of AI in healthcare in India include the under-representation of minority groups in the data used to develop algorithms and solutions; the prominence of males in the software industry, resulting in a male bias in technologies; and greater benefits to higher income populations with access to technologies (47).

Data integrity is another burning issue that requires. Datasets based on large and diverse population would be required to offset bias (48). This could have disastrous effect on increasing the divide in society (49,50). AI design is prone to being a reflection of all the bias that exists in society if care is not taken (50). Algorithms can generate data that may be based on race, gender, age, and religion, resulting in discrimination and unfair results which might be better for some demographics in India than others (51).

Legal liability and attribution of negligence

Liability for AI is also a key issue that needs to be resolved as, currently, liability falls solely on the doctor, rather than the technology (51,52). Explainability, when making its decisions, is very important (52).

Cybersecurity in India

Cyberattacks on all types of organisations globally are on the rise, rendering private digitised data vulnerable to being hacked and accessed by other parties (53,54). In 2016, the laboratory database hacking, resulted in the leaking of over 35,000 patient records from across India. This is despite a prior hack, the laboratory had not taken action to secure the data (55). This requires increase higher standards in data privacy and data security (55,56). There are concerns in India about multinationals accessing to local data, without local benefits. Issues of confidentiality and cybersecurity also need to be addressed, in order to prevent the compromise of sensitive health information (55-57).

High initial cost in AI ventures

In India, the infrastructure required for AI to grow remains inadequate (5-9). Smaller organisations in the health sector also struggle, in particular, with limited resources and insufficient data backup systems (5,7). Start-ups in the medical field also face issues in accessing data from outside of India. Data protection laws, in the EU for example, do not allow for interoperability.

Lack of infrastructure

While the Indian government has increased spending in

the healthcare industry, the amount of public funding it invests in healthcare is small compared to other emerging economies (4). Government investment specifically in health-related AI in India is limited (6). The infrastructure necessary for AI to take off in India remains neglected by policy makers (6). This includes availability of internet and electricity. Hospitals that do not have their own IT infrastructure can produce difficulties for managers using IT technologies (5).

Challenges to data availability in healthcare for use by AI in healthcare

There are several problems facing India the large number of unstructured data sets and problems with interoperability (2). Concerns about the absence of open sets of medical data; inadequate analytics solutions capable of working with big data; and concerns that algorithms may generate data that reflect cultural biases (1,4-6,8,57). Lack of access to open data sets is a particular challenge for start-ups (6). For example, gathering and uploading all the data from intensive care unit monitors, deciphering significant medical patterns and triggering a medical action (4).

Data pooling and data collection

Access to data is essential for AI implementation (6). India has extensive amounts of health data available. India lacks, however, a structured regime in terms of sharing health-related data (57).

A key obstacle to the adoption and implementation of AI in healthcare in India is the absence of robust open sets of medical data. Accessing healthcare datasets can be difficult, legally and due to other reasons. This is a particular challenge for start-ups, in particular, as larger actors often already have access to such data (6). Start-ups thus often rely instead on publicly available datasets from the US, Europe, and elsewhere (6,9,57). This undermines the effectiveness of using AI in healthcare as it does not cater to the Indian demographic (6,50). Reliance on open data from other contexts results in algorithms that reflect the bias of such data and development of solutions trained to a specific demographic (6,8). It would be necessary to adjust for these biases in the application of AI tools and to retrain solutions on Indian data, particularly when it involves drug discovery and genomics (6,8). While there are some scattered examples of open source data in the Indian context, such as the state of Tamil Nadu and the National Cancer Registry, they are insufficient (13).

There is in India a lack of necessary historical health data due to a plethora of reasons. Health records are often hand-written in local languages, which may make it more challenging to digitise (50).

Data protection and privacy

Information privacy concerns are identified as a tremendous obstacle to big data adoption in healthcare in India (4,50). There are concerns in India that international companies in the past have drawn on intangible knowledge from the healthcare sector in India in order to develop a hospital information system using the resources of Indian hospitals. However, these same hospitals were later not able to access these products they helped to develop, having to buy licenses for the next versions of the same or similar products (9).

Consent for collection is a key data challenge (6). Technical deployment seemed to precede policy development, adequate privacy legislation, and ethics constraints (9,45,46,57). The Aadhaar Act [2016] and other existing regulations fail to provide robust consent provisions and address privacy issues in regards to the collection of biometrics (55).

Lack of regulatory compliances and policy guidelines

Problems with standardisation of digitised health data and interoperability, contribute to ineffective health data governance (2,57). While the absence of such regulation has allowed for greater flexibility for start-up companies to collect data and adopt self-regulatory practices of anonymising data prior to further use, the regulatory vacuum produces uncertainty about potential changes (6,9,53).

Insistence of proof of acceptable results in the form of costly and time-consuming clinical trials is a key obstacle for start-ups in India (48,49).

There is a dearth of guidelines regarding data collection in India, however, especially in healthcare (46). This, in addition to errors of data entry and tabulation, is considered to be a key problem—as identified by AI and healthcare practitioners, start-ups and thank tanks at a workshop on AI in India (46).

Regulatory challenges include the need for an appropriate certification mechanism (50). Given that AI is not limited to any one subject or aspect, there is also a need

for self-regulation and/or for the use of different regulators for different aspects—such as medical aspect, or for data aspect (52).

Further, there is no clear regulation to adhere to in conducting such clinical trials (9,53). Certification system can help to build trust amongst health practitioners and patients (9). A possible solution is for doctors and start-ups to partner to conduct clinical trials (6,53). In addition, a 'regulatory sandbox' could be adopted, which is a testing box with relaxed regulations to allow a product to be launched. This can offer an incentive to people working in the field of AI and health to innovate and to receive certification (9,53).

Interoperability

In India, the healthcare industry is rarely standardised, resulting in fragmented and non-standardised clinical data. Implementation of electronic health record policy has yet to be harmonised across relevant segments of the healthcare sector in India. This leads to different interpretations of digitising records and the absence of comprehensive implementation across all hospital data (9,50). The absence of collaborative efforts between various stakeholders exacerbates this obstacle (57).

Lack of partnerships and collaboration

Public-private partnerships are essential, in order to avoid duplication of investment, particularly with limited resources (9,45,46).

Conclusions

With start-ups and large tech companies offering AI solutions for healthcare challenges the use of AI in healthcare in India is exponentially increasing (58). Though developing nations like India lag the superpowers in fundamental research and resources, they enjoy advantages in the form of a vast engineering workforce, a burgeoning startup scene, and a large pool of data waiting to be tapped (59). India also has the entrepreneurial spirit to help businesses derive value from real-time data and the ambition to carve a niche for themselves in an increasingly AI-driven world (60). With the correct navigation of policy space, coordination between different stakeholders, and increased benefits of AI among healthcare leaders the exponential increase in use will become embedded and become a part of the Indian healthcare framework.

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