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Barriers to the adoption of Artificial Intelligence in healthcare in India

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Question

What are the barriers to the growth of the use of Artificial Intelligence (AI) in healthcare within India?

Contents

1. Summary

Artificial Intelligence (AI) has the potential to transform healthcare in various ways. It can turn large amounts of patient data into actionable information, improve public health surveillance, accelerate health responses, and produce leaner, faster and more targeted research and development (Raghupathi and Raghupathi, 2014). More specifically, AI in healthcare can support physicians; automate clinical documentation and image analysis, as well as assist with virtual observation, diagnosis and patient outreach (Gujral et al., 2019; Murali and PK, 2019; Jagdev and Singh, 2015).

There are three broad categories for the uses of AI in healthcare (Paul et al., 2018; Raghupathi and Raghupathi, 2014):

- **Descriptive**: this is currently the most widely used in healthcare technology. It involves quantifying events that have already occurred, and using this data to detect trends and other insights;
- **Predictive**: this uses descriptive data to make predictions about the future, and
- **Prescriptive**: this furthers the purpose of predictive AI, and not only detects trends but also suggests possible treatments in public health or more targeted clinical trials in research and development.

Access to quality healthcare in developing countries, particularly in rural areas, is often a challenge that AI technologies have the potential to alleviate (Kalyanakrishnan et al., 2018). In India, rural populations may lack even basic healthcare facilities. Health technologies, such as telemedicine and AI in healthcare (including the use of robotics), can help resolve these disparities and reach underserved populations (Ajmera and Jain, 2019; Paul et al., 2018). India is in a unique position to be a leader in the AI and healthcare space, with large amounts of data and a growing start-up community specialising in harnessing AI to diagnose disease (Marketwarch, 2019).

The healthcare industry in India is made up of various segments, including hospitals, pharmaceuticals, diagnostics, medical equipment and supplies, medical insurance, and telemedicine (Paul et al., 2018). Stakeholders in the adoption and implementation of AI in healthcare include practitioners, developers, research and industry bodies, government, and funders and investors (Paul et al., 2018). Large companies, such as Microsoft and Google, have also come together to work on a range of initiatives to help build AI infrastructure across the country (Marketwatch, 2019). They have conducted pilots with hospital chains in India (Murali and PK, 2019). Practo, an appointment booking app for patients in India has also been working on automating patient interactions with the use of AI (Murali and PK, 2019).

It is important to explore the barriers to the implementation of AI in healthcare in India, so that it can be implemented successfully across the healthcare industry (Ajmera and Jain, 2019; Paul et al., 2018). While literature related to AI in healthcare in India – and on obstacles specifically - seems to comprise of largely news reports, blog posts and conference and workshop proceedings, there are some academic studies on the topic. In addition, it is possible to draw from other literature on AI in healthcare in low-resource or low and middle income countries (LMICs); and from literature on the implementation of AI more generally in India. However, the literature does not allow for assessment of barriers across different stakeholders, aside from some mention of particular obstacles experienced by start-up companies.

The following are key barriers identified that can affect the implementation and growth of AI across the health sector in India.

- The **substantial cost, initial investment and infrastructure** necessary to implement AI in healthcare is a key barrier. In India, the infrastructure required for AI to grow remains inadequate (Ajmera and Jain, 2019; Panch et al., 2019; Patil, 2018; Paul et al., 2018; USAID, 2019).
- **Challenges to working with big data,** necessary for AI-driven healthcare include: the large number of unstructured data sets and problems with interoperability; 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 (Ajmera and Jain, 2019; Jagdev and Singh, 2015; Mohandas, 2017; NITI Aayog, 2018; Paul et al., 2018; Pinninti and Rajappa, 2020; Raghupathi and Raghupathi, 2014; USAID, 2019). Lack of access to open data sets is a particular challenge for start-ups (Paul et al., 2018).
- **Trust issues and apprehension** with new technologies, particularly among the elderly, are often an obstacle to AI acceptance and usage. There is still a lack of understanding of AI and its benefits, among medical professionals and the general population (Paul et al., 2018, USAID, 2019).
- An **inadequate framework to ensure privacy, security, quality and accuracy of AI solutions** in India is a large obstacle to adopting AI in healthcare. There are concerns in India about international companies gaining access to local data and leveraging it for their own uses, without local benefits. **Issues of confidentiality and cybersecurity** also need to be addressed, in order to prevent the compromise of sensitive health information (Ajmera and Jain, 2019; Bali and Bali, 2020; Gujral et al., 2019; Kamble et al., 2018; Paul et al., 2018; USAID, 2019; Walach, 2018).
- **Regulatory weaknesses and uncertainties remain a challenge**. 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 (Paul et. al; Pinninti and Rajappa, 2020). **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 (Paul et al., 2018; Mohandas, 2017).
- Concerns over **human job losses can contribute to lack of trust**. In the healthcare sector in India, AI is often considered, however, to address the supply-demand gap and to act as an assistant to doctors (Murali and PK, 2019; Paul et al., 2018; Walach, 2018). The **lack of AI trained professionals** can also be a key barrier to using AI in healthcare (Ajmera and Jain, 2019; Patil, 2018).
- **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 (Kalyanakrishnan et al., 2018; Panch et al., 2019; Wahl et al., 2018.

2. Cost, investment, and infrastructure

The advanced digital health infrastructure and automated technologies necessary to implement Artificial Intelligence (AI) in healthcare requires a substantial initial investment (USAID, 2019). This is a key barrier and concern to governments, health systems, potential investors, healthcare organisations and other stakeholders, particularly in lower-resource contexts, including India.

Few stakeholders have the resources to purchase AI tools at a price that would enable financial sustainability for the companies offering them (USAID, 2019).

Public health organisations face mounting cost constraints and challenges in recruiting the talent and resources necessary for the development of artificial intelligence (Panch et al., 2019). Smaller organisations in the health sector also struggle, in particular, with limited resources and insufficient data backup systems (Ajmera and Jain, 2019; Patil, 2018).

A survey conducted among healthcare and engineering professionals in Pakistan found that the cost of using such technologies in healthcare was a major concern (Hoodbhoy et al., 2019). This is similarly the case in India. A study on adopting big data analytics and AI in the manufacturing sector in India finds that cost is a key barrier to adoption, particularly among small and medium industries with inadequate funds for appropriate technologies (Kamble et al., 2018).

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 (Jagdev and Singh, 2015). **Government investment specifically in health-related AI in India is limited** and research is under-funded and explored (Paul et al., 2018). The infrastructure necessary for AI to take off in India remains neglected by policy makers (Paul et al., 2018). Cloud-computing infrastructure, for example, is largely concentrated in servers outside India. **Delays in investing in local infrastructure have resulted in many Indian start-ups incorporating themselves outside India**, where they have easier access to infrastructure and technology (Paul et al., 2018).

Many diagnostic and therapeutic **equipment are also imported from other countries to India, which can lead to software compatibility issues** (Ajmera and Jain, 2019). Hospitals that do not have their own IT infrastructure can produce difficulties for managers using IT technologies (Ajmera and Jain, 2019). In rural areas of developing countries, infrastructure challenges are more pronounced. In some areas, electricity and internet are unavailable, which must be addressed in the designing process (Guo and Li, 2018).

The lack of technological infrastructure throughout India also means that **AI still lacks the deep-learning capabilities that can overcome linguistic diversity** across the country. This can be a significant impediment to the adoption of AI, particularly in healthcare (Paul et al., 2018).

The government should encourage companies and the public sector to invest in AI by providing support and incentives (Paul et al., 2018). **Public-private partnerships are essential**, in order to avoid duplication of investment, particularly with limited resources (Panch et al., 2019; Paul et al., 2018). It is important to align the profit motive of private organisations with social responsibility and the advancement of public health (Panch et al., 2019).

3. Data integrity

Data lies at the core of AI-driven healthcare. Data integrity – the accuracy and completeness of data sets, used to power AI solutions, are essential for accurate and unbiased results (Paul et al., 2018). Access to vital digitised patient data is required to optimise treatment via machine learning technology (Walach, 2018). There are **several challenges in working with big data, including unstructured data, lack of interoperability, and unorganised data** (Gujral et al., 2019). Even if it is possible to afford and implement costly infrastructure and AI tools in resource-poor settings, the efficacy of these tools can be inhibited by **lack of necessary historical health data**

and less health data overall relative to developed markets (USAID, 2019). For many diseases and conditions relevant to resource-poor settings, high-quality datasets that can be used to train machine learning algorithms to identify risk factors or make disease diagnoses can be difficult and time-consuming to collect. Health records are often hand-written in local languages, which may make it more challenging to digitise (Wahl et al., 2018).

Data collection

Data integrity requires particular attention in the Indian context, as a large number of data sets are unstructured and the population is diverse. Specific **cultural biases**, such as caste and sexuality, **could be present in data sets**. It is thus important that the data and input sources on which the AI technology's algorithms are based and trained are derived from a sufficiently large and diverse population (Paul et al., 2018).

There is a **dearth of guidelines regarding data collection in India**, however, especially in healthcare (Mohandas, 2017). 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 (Mohandas, 2017).

Data analysis

Big data in healthcare refers to large and complex electronic health data sets that cannot be easily managed with traditional or software and/or hardware or common data management tools and methods (Raghupathi and Raghupathi, 2014). When big data in healthcare is synthesised and analysed, in order to reveal associations, patterns and trends, healthcare providers and other stakeholders in the healthcare delivery system can develop more thorough and insightful diagnoses and treatments (Raghupathi and Raghupathi, 2014). An obstacle to big data adoption in healthcare is **the absence of an analytics solution powerful enough to gather massive volumes of largely unstructured health data**, perform complex analyses quickly, and trigger meaningful solution (Jagdev and Singh, 2015). For example, gathering and uploading all the data from intensive care unit monitors, deciphering significant medical patterns and triggering a medical action (Jagdev and Singh, 2015).

Big data in healthcare is overwhelming not only due to its volume, but also because of the speed at which it must be managed and the diversity of data types (Raghupathi and Raghupathi, 2014). Data types include various clinical data (e.g. physician's written notes and prescriptions, medical imaging etc.), patient data, machine generated data (e.g. monitoring vital signs), as well as social media posts, web pages etc. (Gudivada and Tabrizi, 2018; Raghupathi and Raghupathi, 2014).

Most available databases are not robust in terms of quality to be used for AI algorithms (Pinninti and Rajappa, 2020).

Lack of open data

Access to data is essential for AI implementation (Paul et al., 2018). India has extensive amounts of health data available (NITI Aayog, 2018). Unstructured data, such as output from medical devices, doctors' notes, lab results, imaging reports, medical correspondence, clinical data and financial, comprises close to 80% of information in the healthcare industry (Jagdev and Singh, 2015, 32). Getting access to this data is an invaluable resource for improving patient care and

increasing efficiency (Jagdev and Singh, 2015). **India lacks, however, a structured regime in terms of sharing health-related data** (NITI Aayog, 2018).

A key obstacle to the adoption and implementation of AI in healthcare in India is the absence of robust open sets of medical data (Gujral et al., 2019; NITI Aayog, 2018). Accessing large medical datasets can be difficult, for legal and other reasons. **This is a particular challenge for start-ups, in particula**r, as larger actors often already have access to such data (Paul et al., 2018). Start-ups thus **often rely instead on publicly available datasets from the US, Europe, and elsewhere** (Paul et al., 2018; Mohandas, 2017). This undermines the effectiveness of using AI in healthcare, however, as the demography represented in the data set is significantly different from the population in India and **does not cater to the Indian demographic** (Paul et al., 2018; Mohandas, 2017). 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 (USAID, 2019; Paul et al., 2018). 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 (USAID, 2019; Paul et al., 2018). 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 (Mohandas, 2017).

Start-ups in the medical field also face issues in accessing data from outside of India. Data protection laws, in the EU for example, prevent interoperability. This has made start-ups wary of the cost and consequences of dealing with medical data (Paul et al., 2018).

Interoperability

A key data challenge for AI healthcare applications in healthcare in LMICs, stems from the general lack of digital health data and integration of data across diverse sources (USAID, 2019). Such AI-enabled tools require data from diverse sources in order to ensure comparability of data, and to produce large training data sets needed for accuracy of algorithms (USAID, 2019).

Healthcare data remains highly dispersed and siloed, spread across a range of organisations – including hospitals, clinics, nursing homes, pharmacies, testing laboratories and IT vendors, and found in incompatible systems and proprietary software (Winter and Davidson, 2019; Walach, 2018). Systems differ even within hospitals across LMICs (USAID, 2019).

This results in the absence of data standardisation and interoperability (the ability of multiple systems or components to exchange information and to use this information). Lack of interoperability represents a key barrier to data sharing and data use – including use in advanced analytics and AI applications, and to the implementation of AI in healthcare (USAID, 2019; Winter and Davidson, 2019; Walach, 2018).

In India, the healthcare industry is rarely standardised, resulting in fragmented and non-standardised clinical data. Although India has adopted an electronic health record (HER) policy, implementation of this policy has yet to be harmonised across relevant segments of the healthcare sector. This leads to different interpretations of digitising records and the absence of comprehensive implementation across all hospital data (NITI Aayog, 2018; Paul et al., 2018). The absence of collaborative efforts between various stakeholders exacerbates this obstacle (NITI Aayog, 2018).

Multiple users

The complexity of extracting medical data increases along with the specificity and ambiguity of medical languages. This difference can cause vernacular mismatches between queries and documents, often rendering AI algorithms ineffective (Gudivada and Tabrizi, 2018). The model needs not only to be trained with the proper domain knowledge to associate related terms, but must also cater to people with and without the medical terminology background, and with and without technical experience (Gudivada and Tabrizi, 2018).

4. Trust issues

Lack of trust is a consistent theme underlying many discussions around AI and other digital health tools in LMICs (USAID, 2019). **Trust issues and apprehension are often an obstacle to AI acceptance and usage** (Paul et al., 2018).

In India, the doctor-patient relationship is often one where the doctor is held in high authority and given complete trust. Patients want doctors to be physically present. This is particularly the case with a significant part of the population poor and illiterate (Paul et al., 2018). The **elderly are also often more averse to adopting new technology**. If doctors are to rely more in AI to inform their decisions and actions, **AI system actions need to be explainable and easily understandable by humans**. This is especially important in healthcare, where diagnosis and treatment must be backed by a solid chain of reasoning to earn patient trust (Paul et al., 2018). There is currently little guidance, however, around when and how to provide explainability – including the range of factors upon which AI bases its decisions, what the desired outcomes are, how AI prioritises needs when making its decisions, and what the logic of a decision taken or recommended by an AI system is (Paul et al., 2018).

Employees working in the health sector may also still be unclear about the potential benefits of AI in terms of value and faster delivery of services. Particularly as certain technologies are still in the early stages of development, with uncertain outcomes (Ajmera and Jain, 2019). AI-based healthcare solutions also often face the issue of **information asymmetry between the doctors who use the system and the coders who built it**, which may result in hesitation among healthcare professionals in adopting the software (Paul et al., 2018).

5. Data protection, privacy, and cybersecurity

Responsible and ethical AI is a key issue that must be considered by developers, practitioners, and policy makers when designing, using, and regulating AI (Paul et al., 2018). **Data security, data privacy and ethical use of data represent global challenges** and are of significant concern in developing countries (Ajmera and Jain, 2019; USAID, 2019; Kamble et al., 2018). This is not only for those working in AI specifically, but also for those working in digital health and other related sectors (USAID, 2019).

India currently does not have an adequate framework to ensure privacy, security, quality, and accuracy of AI solutions, which is a large obstacle to gaining benefits from the adoption of AI in healthcare (Bali and Bali, 2020; Gujral et al., 2019; Paul et al., 2018). Industry professionals have pointed out the importance of standard design guidelines for future AI systems, which is lacking in India (Paul et al., 2018). Existing public health data governance structures in India are unlikely to be sufficient to control the combined momentum of AI, deep learning and data

aggregation, or thus to help channel developments along societally beneficial and equitable directions (Gujral et al., 2019; Winter and Davidson, 2019). Problems with standardisation of digitised health data and interoperability, discussed above, and lack of formal regulation around anonymisation of data, also contribute to ineffective health data governance (Gujral et al., 2019; NITI Aayog, 2018). **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 (Paul et al., 2018).

For further discussion about regulatory issues, see Section 6.

Data protection and privacy

Healthcare information is deemed to be sensitive data under Indian sectoral law (Dixon, 2017). **Information privacy concerns are identified as a tremendous obstacle to big data adoption in healthcare in India** (NITO Aayog, 2018; Jagdev and Singh, 2015). A key step towards ensuring privacy and security of healthcare data is for India is to enact and effectively enforce a comprehensive privacy legislation (Paul et al., 2018). Data privacy issues are particularly important in the health sector since health data is usually government owned, raising **concerns about private companies, particularly larger companies, gaining access to such data and possibly leveraging it for their own uses** (USAID, 2019). 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 (Bali and Bali, 2020).

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 (Bali and Bali, 2020).

Issues of confidentiality also need to be addressed in the context of AI in healthcare. Norms must be established to deal with confidentiality in the doctor-patient-AI relationship, informed consent (for use of and access to personal health data) and standards for AI driven medical research (Paul et al., 2018).

Consent for collection is a key data challenge (Paul et al., 2018). Experience with the roll out of the Aadhaar biometric identity card in India, launched in 2009 and aimed at developing a centralised database with the stated goals of delivering services, reducing fraud and increasing efficiencies, is also concerning in terms of privacy and consent. Research has shown that the lack of protective policy allowed the ID to go from voluntary to mandatory, without appropriate data privacy protections (Dixon, 2017). Technical deployment seemed to precede policy development, adequate privacy legislation, and ethics constraints (Dixon, 2017). The Aadhaar Act (2016) and other existing regulations fail to provide robust consent provisions in regards to the collection of biometrics (Dixon, 2017).

Cybersecurity

The large amounts of confidential health information available online across the cloud computing environment, necessary to adopt AI in the health sector, also pose a security risk. **Cybersecurity concerns represent one of the largest barriers for successful implementation of adopting AI** in the health sector (Ajmera and Jain, 2019). Cyberattacks on all types of organisations globally are on the rise, rendering private digitised data vulnerable to being hacked and accessed by other parties (Ajmera and Jain, 2019; Kamble et al., 2018; Paul et al., 2018; Walach, 2018). The hacking of a Mumbai-based diagnostic laboratory database in 2016, for example, resulted in the leaking of medical records of over 35,000 patients from across India. Despite prior hacks, the laboratory had not taken action to secure the data (Paul et al., 2018).

The security and accuracy of AI solutions in the health sector must be ensured, as the **compromise of highly sensitive health information can have detrimental consequences**, with individual lives at stake (Walach, 2018; Paul et al., 2018). This requires much higher privacy and security standards regulating sensitive personal information in India; robust security protocols and requirements for breach notification, and the development of secure infrastructure by AI companies for processing patient data (Paul et al., 2018; Walach, 2018).

6. Regulatory implications

AI is still an emerging field worldwide. As such, many LMICs lack consistent regulations for the use of AI tools by various actors and AI providers (USAID, 2019). This variability and uncertainty in the regularity environment impedes the scale-up of AI technologies (USAID, 2019).

Regulatory weaknesses are a challenge to the implementation and adoption of AI in India. These challenges include the lack of a Regulating Authority for AI in healthcare, and the need for an appropriate certification mechanism (Paul et al, 2018). 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 for the medical aspect, the Medical Council of India, and for the data aspect, a new regulator under the Data Protection Bill (Mohandas, 2017).

It is also the case that existing legislation in India, and other LMICs, that require physicians to make diagnoses and highly trained health workers to carry out certain medical tests can negate the value of certain AI tools (USAID, 2019).

As with any new technology in healthcare, AI needs to be subject to regulatory approvals relying on clinical trial and evidence-based improvements in clinical outcomes among targeted populations (Pinninti and Rajappa, 2020). **The acceptability of results arrived at using AI is one of the biggest issues with adoption of AI in healthcare in India** (Paul et al., 2018). **Start-ups** in the field often find that they are **required to show proof of a clinical trial** when presenting their products to doctors and hospitals in order to gain the trust of medical practitioners. Yet **clinical trials are not tailored for AI technologies** (e.g. medical devices and digital health platforms) and are both cost and time consuming (Paul et al., 2018). Further, there is no clear regulation to adhere to in conducting such clinical trials (Paul et al., 2018; Mohandas, 2017). An appropriate certification system is required to address the security and quality of healthcare systems driven by AI. It can help to build trust amongst health practitioners and patients (Paul et al., 2017).

A possible solution is for doctors and start-ups to partner to conduct clinical trials (Paul et al., 2018; Mohandas, 2017). 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 (Mohandas, 2017).

Liability and accountability

Laws about liability for AI must be considered, and issues around liability resolved when deploying a digital strategy (Kamble et al., 2018). In the case of error in diagnosis malfunction of a technology, or the use of inaccurate data, a critical question is upon who would the liability fall – 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 (Paul et al., 2018; ; Mohandas, 2017). However, it is unclear how to determine the level of accountability and liability of the doctor when he/she provides the wrong diagnosis and/or treatment due to a glitch in the system or an error in data entry. In the case of AI in healthcare, **many believe that the creator of software should be an agent that can be regulated** (Paul et al., 2018; Mohandas, 2017). There should also be guidance on defining boundaries in healthcare where AI would not be allowed to take over (Mohandas, 2017).

The accurate and unbiased architecture of an AI solution and its underlying algorithm is also important in ensuring responsible AI in healthcare. As India considers a data protection framework, appropriate forms of oversight over algorithms have been considered, with one proposal **suggesting an accountability model that would audit algorithms** to ensure they are privacy neutral and inclusive (Paul et al., 2018).

7. Employment and skills-set

Worker replacement concerns

Concerns that automated and robotic technologies will lead to human job losses can contribute to lack of trust in and support for the adoption of AI in healthcare (Ajmera and Jain, 2019). Negative press reports in India claiming that AI poses a threat to jobs has resulted in difficulty for start-ups to acquire funding (Paul et al., 2018). There is no substantial research, however, to assess the impact of robotics on the employment and motivation of employees in the healthcare sector (Qureshi and Syed, 2014). A survey of professionals in Pakistan finds that few respondents consider the phenomenon of computers replacing human jobs to be a concern or a barrier to using AI in healthcare. The vast majority believed instead that it would help to augment human intelligence (Hoodbhoy et al., 2019).

Some media articles emphasise that **AI-based healthcare initiatives** are not designed to replace doctors in India, but to **serve as assistants to doctors and to bridge the demand and supply gap** between patients and doctors (Murali and PK, 2019; Marketwatch, 2019; Walach, 2018). They are also aimed at extending medical services to traditionally underserved populations in the country, such as in rural areas, and thus to address issues of economic disparity (Marketwatch, 2019).

Skilled workforce

A **skilled healthcare workforce and specialised training are required to handle automated smart machines, digitisation of data, and successful implementation of AI in healthcare** (Ajmera and Jain, 2019). The need to handle sensitive health information very carefully requires a workforce specifically trained to protect data theft (Ajmera and Jain, 2019). Readily available informaticians and analysts may not have the necessary skills to give required support, which can leave a lot of information unaccounted for, and undermine the ability to use AI systems effectively and to determine optimal results (Patil, 2018). A survey of local professionals in Pakistan finds that a **lack of trained AI professionals is the most commonly cited barrier** to using AI in healthcare (Hoodbhoy et al., 2019). This is also considered a key need in the manufacturing sector in India – prerequisite knowledge that cuts across various technical and non-technical disciplines (Kamble et al., 2018). Healthcare sectors worldwide should invest in skills training and development of their human resources, which in turn would motivate the healthcare professionals to work in tandem with robots (Qureshi and Syed, 2014)

8. Inequality concerns

Large datasets are essential to the development of AI technologies, but must be representative of the population to ensure all can benefit (Panch et al., 2019). **Minority groups tend to be less represented in datasets used to develop AI algorithms**. The derivation of health solutions are thus unlikely to be representative of these populations (Panch et al., 2019). These challenges are exacerbated by the fact that many AI algorithms are considered a 'black box' and less likely to be assessed for bias (Wahl et al, 2018).

Some experts have raised **concerns that AI applications in healthcare could exacerbate gaps and inequities in Indian society**, including those related to ethnicity, socioeconomic status and gender (Kalyanakrishnan et al., 2018; Wahl et al., 2018). Cultural prejudices can be reflected in data, algorithms and other aspects of AI design (Wahl et al., 2018). A**lgorithms 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 (Pinninti and Rajappa, 2020).

Issues with bias in datasets are compounded in India by the concern that **gender ratios in India's software industry are heavily skewed**, resulting in the risk that AI technologies to be utilised by the entire population will be produced with a strong male bias (Kalyanakrishnan et al., 2018).

Broader sections of the population, particularly women, linguistic minorities, and rural communities, must be trained in these areas to help reduce the potential for biases and to create and maintain AI systems for their own needs (Kalyanakrishnan et al., 2018; Wahl et al., 2018).

The adoption of AI-enabled healthcare tools also run the **risk of further marginalising underserved populations in the short term as benefits will go initially to higher-income segments of the population** - those with smartphones and 4G connectivity (USAID, 2019). In South Asia, this could also inadvertently exacerbate the gender disadvantage as women are less likely to own a mobile phone than men (Kalyanakrishnan et al., 2018). Further, there are concerns that the high costs of developing AI-based applications may mean that private corporations will be the key drivers. They may be more focused on catering to demographics with larger profit potentials, with no obligation to ensure equitable access (Kalyanakrishnan et al.,

2018). Equity must be central to the development and implementation of AI, and access to AI applications across health systems (Panch et al., 2019)

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