AI in Digital Health

Discussion Paper
Executive Summary

Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

Published by
German Corporation for International Cooperation (GIZ)

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Bonn, October 2022

GLOSSARY

Artificial intelligence (AI): Artificial intelligence has been defined in many ways, but in general it can be described as a way of making a computer system "smart" – that is, able to understand complex tasks and carry out commands. This involves creating algorithms, or sets of rules, to sort and process data. The goal of AI research is to create systems that can learn and adapt on their own, without the need for human intervention. For example, a self-driving car would use AI to interpret traffic signals and other cues in order to navigate safely. Currently, AI is being used in a variety of fields such as medicine, finance, and manufacturing. As the technology continues to develop, it is expected to have an even greater impact on our world.

Machine learning (ML): Machine learning is a branch of artificial intelligence. ML uses known patterns learnt from training data to make predictions about new data. For example, a machine-learning system could be trained on historical weather data in order to predict weather patterns in the future. Machine learning is widely used in many applications, such as email filtering and computer vision. In general, any task that requires prediction or classification can benefit from machine learning.

Deep learning (DL): Deep learning is a subfield of machine learning that is concerned with algorithms inspired by the structure and function of the brain called artificial neural networks. Neural networks are interconnected networks of nodes, similar to the way neurons are interconnected in the brain. These networks are capable of learning to recognize patterns of input, which can then be used for classification or prediction. Deep learning architectures have been successful in a variety of tasks such as image recognition, natural language processing, and voice recognition. Deep learning models are difficult to interpret by humans and decision making of deep neural networks are similar to a black box.

EXECUTIVE SUMMARY

INTRODUCTION

Artificial intelligence (AI) will transform healthcare. It may enhance medical outcomes, patient satisfaction, and access to care. It has the potential to increase the productivity of healthcare professionals and allows organisations to proactively manage population health, direct resources where they will have the greatest impact, and encourage speedier treatment delivery, particularly by reducing diagnostic time. In recent years, concerns have been expressed regarding the influence of AI on practitioners, ethics, the terms of use of personal data, and other AI-related hazards.

With a focus on German Development Cooperation, this discussion paper presents current issues and trends of AI in healthcare with regard to low- and middle-income countries (LMIC). The main goals are to clarify the scope and effect of AI in healthcare, provide a framework for understanding AI systems, present selected initiatives and projects, identify regulatory and ethical issues and gaps, outline recommendations for German Development Cooperation, and inform cooperation with partners.

The paper is based on current publications on AI in healthcare with an emphasis on LMICs, interviews with selected stakeholders from the development cooperation sector and partner countries, as well as internal discussions and workshops of the GIZ Sector Initiative Global Health / Digital Health.

BACKGROUND

The term AI is broadly used and has numerous different application areas and technological foundations. This discussion paper focuses on narrow AI, more specifically machine learning (ML) and deep learning (DL) algorithms, which by far enable the most relevant use cases for practical AI applications today. ML is a broad phrase for the automated production of knowledge in the form of rules based on prior experience: An artificial system learns from example data and answers, and after the learning phase is complete, it can generalize them. ML means using known patterns learnt from training data to make predictions about new data. This means that it recognizes patterns and laws in the learning material rather than merely memorizing the examples. Therefore, an ML system might be able to identify cancer on an unknown medical image, because it was trained with many other images.

BUILDING BLOCKS

AI is the simulation of human cognitive abilities using technical aids. However, such a definition is ineffective in practice. What is required is a practical method for making the term AI suitable for use in organisations and to support policy experts who shape the framework conditions for AI usage. One attempt is the "periodic table of artificial intelligence," which maps the concept of AI to business processes to build an understanding of the elements. In this sense, AI is viewed as a combination of fundamental elements, similar to different LEGO bricks. There are a total of 28 AI elements defined, which can be combined based on general criteria. Each AI element is classified into one of three categories:

- Assess (e.g., detect the traffic situation around a robot car in milliseconds),
- Infer (e.g., calculate the probability of a rear-end collision for the next 3 seconds), and
- Respond (e.g., initiate the braking or evasive manoeuvre of the robot car).

USE CASES

AI can be found in all areas of healthcare, including activities, facilities, people, processes and regulations that deal with health, health impairment, diseases, the restoration of health, as well as planetary health. From a practice-oriented point of view, the use of AI in health is mostly considered in the process of treating patients or in diagnosis.

Figure 1: Use of AI in the patient journey (example)

	Screening	Preventive Care	Diagnostics	Therapy	Monitoring	Aftercare
Goals	Prevent, detect and treat diseases, stop disease progression	Detect and eliminate health risks at an early stage	Identify a disease through questioning and evaluating findings	Help to enable or accelerate healing process of a disease	Improve treatment outcomes by identifying and correcting problems	Support patient after therapy and identify critical conditions
Typical AI use cases	AI to assist doctors by prioritizing, taking over standard tasks, monitoring screening and increasing overall process quality	AI to assist patients by early detection and making individual recommendations, as well as offering health status information	AI to help doctors make diagnoses, perform routine medical exams, and make better decisions based on large medical data sets	AI to predict patient response to a therapy, assist during therapy and assess whether medicines work with various treatment plans	AI to monitor critical situations, e.g., trigger an alarm to alert staff or continuously track vital functions and recommending actions	AI to help patients organize appointments and follow-up plans, remind to take medications, and organize reports and patient files

Source: Own presentation

Examples of AI applications in the broader healthcare sector with their position in the healthcare system are shown in the following figure:

Figure 2: Examples of AI applications in the broader healthcare sector

Inpatient and outpatient care	Production and supply	Management and research	Individual citizens
Hospitals ▶ Image analysis ▶ Surgical robots	**Pharmaceutical industry** ▶ Drug development ▶ Acceleration of studies	**Health insurance** ▶ Workflow automation ▶ Financial auditing	**Fitness and wellness** ▶ Health apps ▶ Activity tracker
Pharmacies ▶ Stock optimisation ▶ Patient screening	**Medical devices industry** ▶ Digital twins ▶ Precision medicine	**Ministries and administration** ▶ Expert systems ▶ Automation of applications	**Prevention** ▶ Symptom checks ▶ Wearables
Rehabilitation centres ▶ Exoskeleton ▶ Monitoring	**Logistics and supply chains** ▶ Autonomous driving ▶ Navigation systems	**Universities** ▶ AI writing bots ▶ Exams and assessments	**Health education** ▶ Virtual reality ▶ Augmented reality
Medical practices ▶ Virtual doctors ▶ Decision support	**Information technology** ▶ IT automation ▶ Cybersecurity	**Research and development** ▶ Behavioural predictions ▶ Data analytics	**Assistance systems** ▶ Smart home ▶ Monitoring
Care facilities ▶ Nursing robots ▶ Fall detection	**Specialised trade and retail** ▶ Dynamic pricing ▶ Inventory controls	**Education and training** ▶ Mobile learning ▶ Conversational interfaces	**Assisted living** ▶ Service robots ▶ Voice assistants

Source: Own presentation

STAKEHOLDERS

The landscape of stakeholders around AI-related topics in emerging economies is diverse, complex, and highly fragmented. When it comes to AI in general, different stakeholder groups can be differentiated, depending on their activities, strategies, and roles. The following table gives an overview of the most relevant stakeholder groups. Most of the use cases discussed previously fall into the group of “Using AI”, i.e. healthcare organisations, healthcare facilities, healthcare companies, and patients.

Table 1: Stakeholder groups in AI

STAKEHOLDER GROUP	ACTIVITY	LEADING QUESTION	EXAMPLES
Leading AI	Innovating and improving AI	How can we create AI breakthroughs?	Big tech companies
Researching AI	Analysing and evaluating AI	What could AI do in the future?	Universities, institutes
Developing AI	Implementing AI systems	How should AI systems be designed?	Tech firms, developers
Using AI	Applying AI to solve business problems	How does AI aid decision-making?	Organisations of all kinds
Regulating AI	Setting policies for the use of AI	How can AI be used fairly and legally?	Policy makers, regulators
Funding AI	Supporting and investing in AI projects	What is the impact of an AI project?	Incubators, VCs, donors
Enabling AI	Providing the technological basis for AI	What technology does AI need?	Hardware manufacturers
Educating AI	Offering advice on the use of AI	How can we facilitate the use of AI?	Consultants, trainers

Source: Own presentation

REGULATIONS

At least 60 countries have adopted some form of AI policy since 2017, when Canada became the first to do so. Work on developing global AI standards has resulted in significant developments in various international bodies. Furthermore, there has been an increase in the number of declarations and frameworks issued by public and private organisations to guide the development of responsible AI. While many of these are focused on broad principles, the last years have seen an increase in efforts to put these principles into action through fully-fledged policy frameworks. Frontrunners in this regard have been Canada's directive on the use of AI in government, Singapore's Model AI Governance Framework, Japan's Social Principles of Human-Centric AI, and the United Kingdom's guidance on understanding AI ethics and safety; they were followed by the United States' guidance to federal agencies on AI regulation and an executive order on how these agencies should use AI. The most recent attempt to introduce a comprehensive legislative scheme governing AI was the EU proposal for adoption of regulation on AI.

DATASETS

When it comes to the use of AI in healthcare, the dominating issue across most LMIC stakeholder groups are usually issues and concerns around data quality and security, the interoperability of systems, and the governance and ownership of data.

Therefore, the main challenges are:

- **Digitisation of health data:** A lack of digital records and processes poses significant challenges for adopting AI solutions. Before launching AI efforts, it is critical to focus on the basic digitisation of systems and data, as well as the development of digital skills.
- **Data governance:** As more healthcare is delivered using new digital technologies, public concern about the use of healthcare data has grown. Healthcare organisations should have robust and compliant data-sharing policies in place that support the improvements in care that AI provides while also providing the necessary safeguards.
- **Data interoperability:** Healthcare data is notoriously difficult to manage. It is frequently collected using proprietary software and compiled in siloed databases that are part of largely incompatible systems. Healthcare systems and providers must develop policies to promote interoperability both within their own proprietary systems and those of external parties.

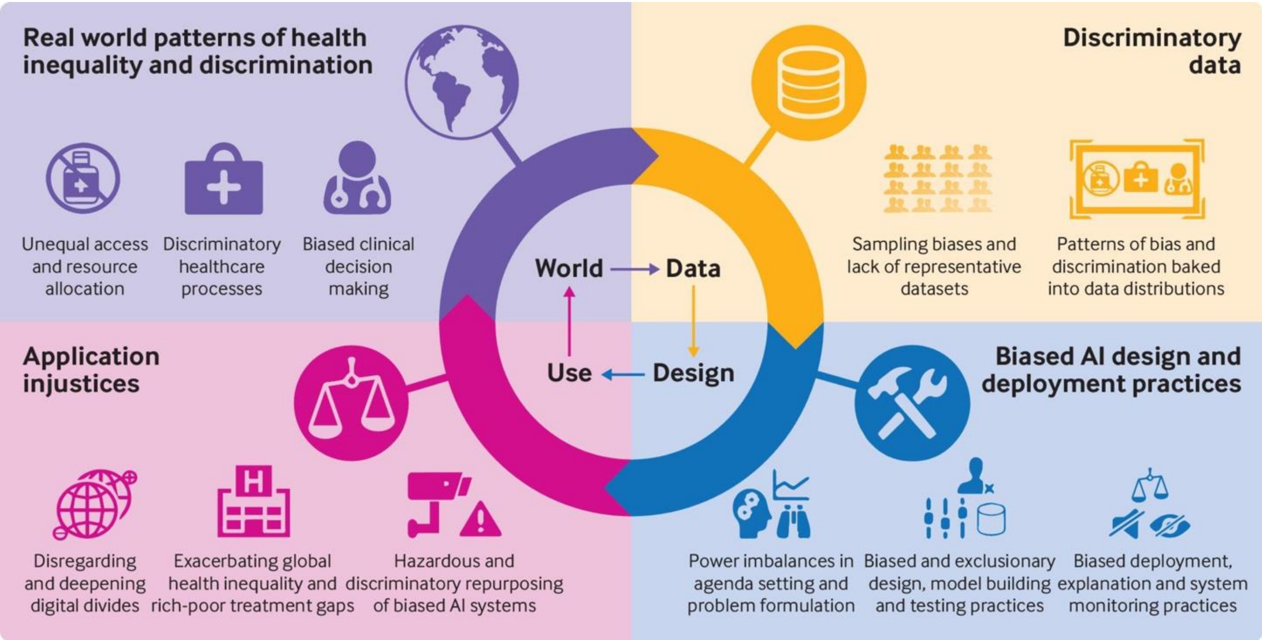
ETHICAL ISSUES

There are multiple ethical issues when it comes to using AI in general and even more so in relation to healthcare; among the most discussed ones are the following:[1]

- **Uncertainty and distrust of AI predictions**
  How was the recommendation made and is it really correct?
- **Regulation and governance of medical AI**
  Is the AI system trustworthy and who can ensure this?
- **Shifts in responsibility and liability introduced by using AI in practice**
  Who is responsible for decisions, and will my doctor follow the AI?
- **Concerns for data privacy and security**
  How can I be sure my data will only be used with my consent?
- **Biased results that hurt marginalized groups**
  Do the datasets and algorithms apply to my personal context?
- **Underlying business model and ownership**
  Who benefits from using a specific AI system and who owns the data?

AI systems have the potential to increase health inequities if they are not carefully built and implemented. There can even be a cascading impact of inequality and in the design and application of an AI system, as shown in the following figure:

Figure 3: Cascading AI bias in healthcare applications



Source: British Medical Journal[2]

Depending on the implementation setting, some biases are unavoidable while others can be mitigated. In any case, to effectively identify bias, the presence of bias throughout the whole AI pipeline needs to be mitigated.

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[1] Topol, Eric: AI in health and medicine, Webinar, AI for Good, streamed live on 27 April 2022, https://www.youtube.com/watch?v=Z8A73pUr3aA (accessed 11 May 2022).

[2] British Medical Journal (2021): Does “AI” stand for augmenting inequality in the era of covid-19 healthcare?

GAP ANALYSIS

The following main issues for AI in healthcare have been identified with regards to LMIC:

- **Data availability and quality:** AI/ML applications require a training dataset with defined outcome variables. In LMIC, there is often a scarcity of locally generated usable data. Moreover, many AI applications are created in high-income countries with datasets that is often not directly applicable to population in LMIC (or there is a lack of appropriate medical evidence).
- **Regulation of AI:** Some LMICs lack a national digital health policy or plan to guide the implementation and monitoring of digital health strategies. Stakeholders from partner countries often feel that limited government policy participation has impeded adoption, and that greater engagement could stimulate early use of AI and other digital tools.
- **Costs of AI-based solutions:** The cost of assembling an AI/ML-based solution in healthcare is difficult to estimate but can be very high, depending on the setup and intended outcome. Data acquisition and preparation costs are typically the most critical and time-consuming aspect that fundamentally determines the quality of an AI application.
- **Inadequate infrastructure:** Another key barrier restricting the rate of growth of this technology in LMICs is insufficient infrastructure, e.g., low internet penetration and energy inaccessibility, making it difficult to implement and sustain digital technologies in all sectors of the economy, including healthcare.
- **Lack of skills on site:** One of the major challenges is the lack of local skills. In order to implement AI healthcare systems, trained personnel are needed to develop, operate and maintain the systems. However, there is a shortage of suitable experts in many LMICs, due to the lack of education and training opportunities in these countries.

CONCLUSIONS

The potential of AI and ML to significantly improve healthcare should not be underestimated. In LMIC, the application of AI-driven tools can aid in the eradication of health disparities and alleviate the strain on health systems.

However, AI is empowered by data, knowledge and technology. The foundational elements for planning and implementing AI systems are therefore a vast amount of quality training data (big data), knowledge about the applicability and structure of data for AI (data science), and access to computing resources (cloud computing). While the latter is typically easy to solve (given sufficient internet access), the first two topics are often overlooked. Nonetheless, they are a basic prerequisite for the effective application of AI in any use case.

Overall, the following main enablers for AI adoption and implications for healthcare systems in LMICs should be taken into account:

Figure 4: AI-related recommendations for healthcare systems

Enablers for AI adoption	Implications for healthcare systems
▪ Quality and suitability of solutions	▪ Develop national AI strategy for healthcare
▪ Education and training	▪ Define use cases to support through funding and incentives
▪ Data quality, governance, security, interoperability	▪ Set standards for digitisation, data quality, data access, governance, security, interoperability
▪ Change management	▪ Redesign workforce planning and clinical education processes
▪ Talent	▪ Provide incentives and guidance for healthcare organisations
▪ Regulation, policy making, liability	▪ Address AI regulation, liability and funding issues
▪ Funding	

Source: Own presentation

AI stakeholders must continue to increase their capacity, since the pace of change and potential for disruption brought on by AI cannot be understated. It will be crucial to give important decision-makers the knowledge they need to comprehend the fundamental operations of AI and ML, the issues that may be fixed, and the areas where expectations are incorrect. This covers not just technology elements but also the strategic and operational setups required to conduct AI initiatives successfully.

While finding AI-based application sectors is crucial, supporting regulatory systems will be an important task, too. Multinational collaboration will be essential in defining and creating standards and best practices in this context.

While many of the AI-related developments will take place in the upcoming years, other, more fundamental changes regarding the capability of AI applications will take longer to manifest. There is great potential for disruption through the use of AI in the healthcare sector over the medium to long term. Widespread usage of AI could radically alter current systems. This might also lead to significant hazards that have to be handled by stakeholders on all levels, especially when combined with the influence of other emerging technologies. The use of AI requires both international coordination and worldwide co-operation due to its global character.

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