IMPACT OF ARTIFICIAL INTELLIGENCE ON DIGITAL HEALTH IN BRAZIL

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1- The term Artificial Intelligence (AI) refers to digital systems, designed to emulate models of thought, decision and/or action similar to those of human beings, including programming languages, codes, algorithms and computer programs, based on logic parameters pre-programmed, adjusted or learned in the processing of information. The main benefit of AI algorithms is that, implemented to reproduce certain aspects of human thinking in general patterns of conduct, they can handle various types of structured or unstructured data input aimed at solving specific problems. Currently, AI constitutes one of the main health digital technologies, cutting across all areas of Digital Health, from the management of health systems (e.g., complex accounting systems involving funders, buyers, providers, payers, patients, etc.,) feeding search engines, analyzing data, guiding decisions and making recommendations to the health care ecosystem through clinical and public health-related applications. AI can be incredibly powerful to process (e.g., using pattern recognition or predictive capabilities) massive volumes of data, or *big data*, that are increasingly readily available on data platforms stored through personal, institutional, or official digital devices.

2- There are several modalities of AI. *Machine learning* (ML) is the most common form; it is a method used to train a computer program from real or simulated datasets without programming it directly or it can be used to replicate the behavior learned in processing new data. Deep learning and *adversarial machine learning* involve ways of self-training the program to reveal underlying patterns in the data being analyzed or to create new patterns or configurations (e.g., algorithms used to find clusters, variations, or equivalences in data). *Deep learning* is a subset of ML that employs layers of incoming raw data and processing cycles to extract new data and reprogram the algorithm to new criteria and patterns. *Adversarial machine learning* consists of running a ML program, or some of its algorithms, in permanent competition in processing cycles, resulting in instructions and solutions to inconsistencies and contradictions generated in the resulting logical confrontation. There are several approaches to ML, including:

a. Supervised ML: Learning begins with a set of predicted inputs and corrected outputs, to which new codes are added.
b. Semi-supervised ML: for some classes of data there is a lack of labels, aggregated during the training process.
c. Unsupervised ML: only the input parameters are provided, and the algorithm groups or generates the data, giving it an autonomous structure.
d. Self-reinforcing ML: learning by trial-error iterative cycles, without input data.

3- AI programs designed to generate communicational objects (words, sentences and texts in natural language; codes in programming language; sounds and music; images; transcriptions and translations) are conversational word transformers called Large Language Models (LLM) (examples: ChatGPT, Gemini, others) which

have become targets of recent hype in the media that needs serious demystification. In general, despite its great applicability, immense potential and varied functionalities, AI has serious limits and faces difficulties in incorporating, in its repertoire of executive interfaces, subjective elements of human beings' thinking and acting or the influence of motivational dimensions in complex social systems (such as sensitive and humanized modes of health care). While these new technologies are indeed promising, the rapid development of this field raises ethical, legal, and societal concerns about privacy, reliable information, appropriate uses, social responsibility, equitable access, bias, and inclusion.

4- In 2019, an Expert Group on Artificial Intelligence at OECD proposed AI principles, pointing out ideal properties for AI modeling: fairness; explainability; robustness; performance. In addition, a classification of typical AI tasks was established: recognition, event detection, forecasting, personalization, interaction support, goal-driven optimization, reasoning with knowledge estructures. Considering these criteria, AI might enable multiple applications for Digital Health, both at the individual (Precision Medicine) and at the collective level (so-called Precision Public Health). These applications covers all dimensions of health care, such as: improvements in diagnostic accuracy; prediction of prognosis based on modeling and use of deep learning to predict recovery rates; detection of adverse drug effects; clinical follow-up applications; optimization of rehabilitation processes; patient flow in referral and counter-referral systems; automated detection of acute conditions; improving the quality of care; reduction of health care costs; prediction of risks for the promotion of health and well-being of the population.

5- Notwithstanding its applicability and transformative potential for health care practices and in planning and management in the health and care field, AI in Health was mentioned only in passing in the Brazilian Strategy for Artificial Intelligence, in a superficial way, in the space intended for "applications in the productive sectors" (Brasil, 2021, p.38). This situation has changed and now AI is listed among five dimensions of priority action, among the initiatives of the new federal government, which resulted in the creation of a new Secretariat of Information and Digital Health at the Ministry of Health. AI is one of the pillars of the SUS Digital Health Program: investments in infostructure (connectivity, equipment); electronic records applications; telehealth-telemedicine; big data platforms; artificial intelligence. The Artificial Intelligence in Digital Health (AI/DH) initiative has Vieira-Pintos' critical theory of technology and the Informational Realism approach as a conceptual basis. As far as the SUS Digital Care Ecosystem is concerned, several projects are projected and/or under development: intelligent systems for diagnosis, prognosis and remote monitoring; tele-health with Meta-Presential Care Spaces (EMC); mobile-health apps such as "Meu SUS Digital". For promoting a digital culture framework, a training national program based on AI/DH is being designed. As for scientific research, the priority goes to RD&I on forecasting and precautionary prevention, RD&I of ML algorithms and programs for data analysis, studies on the impact of AI on society and on the economy, as well as AI/DH studies on Monitoring Digital Transformation of the health system.

AREAS-THEMES ACTIONS	INFOSTRUCTURE: CONNECTIVITY, EQUIPMENT	TELEHEALTH TELEMEDICINE CORRELATES	ELECTRONIC RECORDS APPLICATIONS	BIG DATA PLATFORMS	ARTIFICIAL INTELLIGENCE AI/HEALTH
(a) Theoretical-conceptual basis	PLACTED; theory of the Health Industrial Complex	Theory of Presence; Meta-presentiality	Theory of technique; Actor-network theory (Lévy, Latour)	Theory of the modes of production of knowledge (Samaja)	Theory of Informational Realism (Floridi, Minger)
(b) SUS Digital Care Ecosystem	Revision of the hierarchical infostructure of the SUS	Meta-Presential Care Spaces (EMC)	e-health m-health Meu SUS Digital	Platforms DATASUS CIDACS RNDS Other	Intelligent systems for diagnosis and prognosis
(c) Training people in digital culture	Meta-Presential Learning Spaces (EMA)	Training metapresencial Humanization at DH	Registration, sensor, and app design training	Training in Health Informatics Epidemiology at DH	Programming training for AI/DH
(d) Scientific and technological production	DH Innovation Labs	RD&I of networks, protocols, and programs	Design devices & programming RD&I	Data Engineering and Information Platforms	PD&I of ML algorithms and programs
(e) Social and cultural factors	Research Networks on the Impacts of Digital Health	Satisfaction, adherence and effectiveness studies	Socio-technical appropriation studies	Prospective and predictive analytics studies	RD&I on precaution and the impact of AI on society
(f) Political and institutional impacts	SUS Digital Transformation Laboratories	Intervention and evaluation studies	Implementation and operation studies	Studies on the impact of DH on the population	AI/DH Digital Transformation Monitoring
(g) Effects on the economy	Economic Impact Observatories	Cost-effectiveness studies	Meta-care Monitoring Studies	Integration with databases – IBGE IPEA	impacts of AI/DH on the economy
h) Legal and regulatory aspects	DH Regulation Observatories	Deontological studies of telehealth	Studies of ethical-legal aspects	Studies on data protection policies	Regulatory Trends and Solutions for AI/DH

5- Finally, scope reviews of regulatory trends and a prospection of solutions for AI/DH participatory social control are imperative and urgent. In the specific context of Digital Health, ethical and privacy issues dominate the concerns of planners, managers, operators, and users of health systems regarding artificial intelligence and its perils. No doubt that machine learning algorithms and AI/DH applications pose new ethical challenges for policymakers, social activists and innovators struggling to strike an optimal balance against the rights of users of digital health ecosystems. Many of these questions about the ethical development and political use of these technologies in the context of digital capitalism and its neocolonialism remain open, including whether, when and how poor, excluded social groups of peripheral countries will benefit from them.

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