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# ARTIFICIAL INTELLIGENCE IN HEALTHCARE: BIOETHICAL CHALLENGES AND APPROACHES

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**Abstract**

Artificial Intelligence systems are increasingly introduced in healthcare practice. After defining artificial intelligence (AI) and discussing a few examples of its implementation in healthcare, the essay focuses on ethical challenges and on the currently proposed ethical approach outlined in international documents and centred on principles. Without dismissing such an approach, healthcare practice will benefit from integrating a principle-based approach with a stronger focus on fostering virtuous moral agents and on virtuous contexts that aim at promoting the common good.

**Keywords:** Artificial Intelligence; Common Good; Healthcare Ethics; Theological Bioethics; Virtues

## Introduction

In the Indian city of Madurai, in the state of Tamil Nadu, the Aravind Eye Hospital treats anyone, whether they can pay or not–usually, over 2,000 people each day. Many of these persons need to check their retinas for diabetic retinopathy, to exclude any possible

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damage to their retinas caused by diabetes (both type 1 and 2 diabetes). According to 2018 data, of the 1.3 billion Indian citizens almost 70 million suffer from diabetes.[1] They are all at risk of blindness—one of the major complications of diabetes. Hence, screening is urgently needed. But in India there are not enough eye doctors. 2016 data of the International Council of Ophthalmology indicate that in India, for every one million people, there are only eleven eye doctors.[2]

Lacking eye doctors, technicians could screen patients. To facilitate screening, Google offered artificial intelligence systems to detect signs of illness and disease in eye scans. Artificial intelligence (AI) relies on neural networks, "which are complex computer algorithms that learn tasks by analyzing vast amounts of data."[3] Hence, "By analyzing millions of retinal scans showing signs of diabetic blindness, a neural network can learn to identify the condition on its own."[4] The Google's eye system used in Madurai has been approved for use in Europe, but not yet in the U.S.A. However, this AI system does not replace eye doctors. Trained ophthalmologists still need to verify and assess the information provided by the AI screening system.[5]

As this example suggests, AI systems could play an important role in global public health by expanding the screening possibilities, facilitating diagnoses, and complementing healthcare practice. Hence, AI systems could contribute to promote high quality health services focused on health prevention, promotion, and care. Globally, the good of personal and social health would be fostered. Google's engagement in providing its eye system, and the Indian willingness to test it in their hospitals, are praiseworthy. One wonders, however,

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[1]See India State-Level Disease Burden Initiative Diabetes, "The Increasing Burden of Diabetes and Variations among the States of India: The Global Burden of Disease Study 1990-2016," *Lancet Global Health* 6, 12 (2018) e1352-e1362.

[2]See International Council of Ophthalmology, "Number of Ophthalmologists in Practice and Training Worldwide," (2020) http://www.icoph.org/ophthalmologists-worldwide.html.

[3]C. Metz, "Google Researchers Are Learning How Machines Learn," *The New York Times*, March 6, 2018.

[4]C. Metz, "India Fights Diabetic Blindness with Help from A.I.," *The New York Times*, March 10, 2019.

[5]See V. Gulshan et al., "Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs," *JAMA* 316, 22 (2016) 2402-2410; Y. Guo et al., "Development and Validation of a Deep Learning Algorithm for Distinguishing the Nonperfusion Area from Signal Reduction Artifacts on OCT Angiography," *Biomedical Optics Express* 10, no. 7 (2019) 3257-3268.

whether in India and in other countries in a similar situation, there is an equal or even stronger effort to train ophthalmologists to address the patients' needs in each country. Before examining other examples of AI in healthcare, how do we define artificial intelligence?

**Definitions**

According to the 2019 report of the High-Level Expert Group on AI of the European Commission, artificial intelligence systems are software designed by humans that depend on algorithms and on artificial neural networks. These systems perceive their environment, acquire and interpret data, reason on and process information, and decide the best action to achieve the given goal. AI systems can also adapt by analyzing how the environment is affected by their previous actions.[6]

To consider a quite different definition, for the Irish-based business multinational company Accenture, "Artificial Intelligence… is a collection of multiple technologies that enable machines to sense, comprehend and act–and learn, either on their own or to augment human activities."[7]

In both definitions we notice that specific human abilities are evoked: whether we stress the ability to reason, learn, analyze, and adapt, as in the first definition or, in the second definition, "to sense, comprehend and act–and learn." Hence, we could say that artificial intelligence is a collection of systems that we design and produce, but that we expect will be able to enact some of our human capabilities, particularly those belonging to our rationality and intelligence, and that will continue to learn and adapt, well beyond our initial designing and programming.

In defining artificial intelligence, we might agree that the adjective "artificial" is appropriate—we build these systems. One wonders, however, whether it is correct referring to algorithms and neural

[6] "Artificial intelligence (AI) systems are software (and possibly also hardware) systems designed by humans that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal. AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions." High-Level Expert Group on AI, *Ethics Guidelines for Trustworthy Artificial Intelligence*, Brussels: European Commission, 2019, 6.

[7]https://www.accenture.com/us-en/insight-artificial-intelligence-future-growth.

networks as "intelligence," except if we consider "intelligence" in metaphorical ways.

**Why Should We Bother?**

What are the ethical implications of designing and producing AI systems that attempt to mimic, replace, or even expand some human capabilities? Do these attempts change our ways of considering who we are as human beings? Are we the sum of multiple mechanical or neural functions that could be reproduced in AI systems?

To focus on AI and on human beings also means to consider how artificial intelligence is already present in the social fabric in diverse ways that can be remarkable but also troubling. In this essay I discuss a few examples in healthcare. Ethically, I consider a current approach and, then, I propose one that aims to promoting the common good. Current developments in artificial intelligence invite us to reflect critically on who we are as human beings, on how we act, and on our society, with its current dynamics and power struggles. In doing so, we might be able to positively influence the ongoing development of AI technology and assess its applications by protecting individual human beings and the whole society.

**Using Artificial Intelligence in Healthcare**

In February 2019, in the U.S.A., President Donald J. Trump signed the "Executive Order on Maintaining American Leadership in Artificial Intelligence," [8] by stressing that the development and regulation of artificial intelligence is a federal priority. In healthcare, however, artificial intelligence is already playing increasingly important roles from prevention to diagnoses and therapies.[9]

In 2019, colleagues at the Massachusetts Institute of Technology and Massachusetts General Hospital "created an AI system to improve the detection and diagnosis of lesions seen on mammograms" to avoid false positive results that lead to unnecessary biopsies and surgeries. The team's system "uses machine learning to detect similarities between a patient's breast and

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[8]D.J. Trump, "Executive Order on Maintaining American Leadership in Artificial Intelligence," https://www.whitehouse.gov/presidential-actions/executive-order-maintaining-american-leadership-artificial-intelligence/ (2019), https://www.whitehouse.gov/presidential-actions/executive-order-maintaining-american-leadership-artificial-intelligence/.

[9]See G. Shapiro, *Ninja Future: Secrets to Success in the New World of Innovation*, New York: William Morrow, an imprint of HarperCollins, 2019; A. O'Connor, "How Artificial Intelligence Could Transform Medicine," *The New York Times*, March 11, 2019.

a database of 70,000 images for which the malignant or benign outcome was known."[10] This early-detection technology is also tested in other hospitals across the country.

Together with breast cancer, cardiovascular outcomes[11] and other cancers can be detected, for example, prostate cancers[12] and lung cancers[13] as well as "spots that might later become cancer, so that radiologists can sort patients into risk groups and decide whether they need biopsies or more frequent follow-up scans to keep track of the suspect regions."[14] However, tumours can also be missed or benign spots can be mistaken for malignancies causing "invasive, risky procedures like lung biopsies or surgery."[15] In the case of brain tumours, brain surgeons rely on artificial intelligence and new imaging techniques "to diagnose tumours as accurately as pathologists, and much faster" helping them to perform their operations.[16]

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[10]J. Morrissey, "Looking to Technology to Avoid Doctors' Offices and Emergency Rooms," *The New York Times*, February 21, 2019. For a study examining images from 7,522 of the 143,238 women in the U.S. and the U.K., see S.M. McKinney et al., "International Evaluation of an AI System for Breast Cancer Screening," *Nature* 577, 7788 (2020) 89-94.

[11]See I.J. Cho et al., "Development and External Validation of a Deep Learning Algorithm for Prognostication of Cardiovascular Outcomes," *Korean Circulation Journal* 50, 1 (2020) 72-84; J.M. Kwon et al., "Development and Validation of Deep-Learning Algorithm for Electrocardiography-Based Heart Failure Identification," *Korean Circulation Journal* 49, 7 (2019) 629-639.

[12] See K. Nagpal et al., "Development and Validation of a Deep Learning Algorithm for Improving Gleason Scoring of Prostate Cancer," *NPJ Digital Medicine* 2, 48 (2019) 10.1038/s41746-019-0112-2.

[13]See D. Grady, "A.I. Took a Test to Detect Lung Cancer. It Got an A," *The New York Times*, May 20, 2019. See also D. Ardila et al., "Author Correction: End-to-End Lung Cancer Screening with Three-Dimensional Deep Learning on Low-Dose Chest Computed Tomography," *Nature Medicine* 25, 8 (2019) 1319; D. Ardila et al., "End-to-End Lung Cancer Screening with Three-Dimensional Deep Learning on Low-Dose Chest Computed Tomography," *Nature Medicine* 25, 6 (2019) 954-961; J.G. Nam et al., "Development and Validation of Deep Learning-Based Automatic Detection Algorithm for Malignant Pulmonary Nodules on Chest Radiographs," *Radiology* 290, 1 (2019) 218-228.

[14]Grady, "A.I. Took a Test to Detect Lung Cancer. It Got an A."

[15]Grady, "A.I. Took a Test to Detect Lung Cancer. It Got an A."

[16]T.C. Hollon et al., "Near Real-Time Intraoperative Brain Tumor Diagnosis Using Stimulated Raman Histology and Deep Neural Networks," *Nature Medicine* 26, 1 (2020) 52-58. On AI and imaging, see also D. Visvikis et al., "Artificial Intelligence, Machine (Deep) Learning and Radio(Geno)Mics: Definitions and Nuclear Medicine Imaging Applications," *European Journal of Nuclear Medicine and Molecular Imaging* 46, 13 (2019) 2630-2637. Regarding AI in radiomics (i.e., converting radiologic images into data and analyzing these data to support medical decision-making), see A. Barucci and E. Neri, "Adversarial Radiomics: The Rising of Potential Risks in

Other applications of AI can be mentioned. First, artificial intelligence is used to diagnose degenerative diseases like Alzheimer's disease.[17] Second, in operating rooms, AI helps to guide robots and augments the precision of surgeons in their complex surgeries.[18] Finally, in drug research, by examining more than 100 million molecules, AI identifies new types of antibiotic effective against a wide range of bacteria now considered untreatable, including resistant strains of tuberculosis. A new antibiotic, called halicin, is the first discovered with artificial intelligence.[19]

AI could also have an even deeper impact on healthcare practice. In his 2019 book *Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again*, Dr Eric Topol stresses how artificial intelligence is more beneficial to healthcare than simply enhancing research, prevention, diagnoses, and treatments. It can help doctors "To restore the care in health care"[20] by "giving both the gift of time to clinicians, who are at peak levels ever recorded for burnout and depression, and empowerment to patients."[21] Two concrete examples are reading scans and taking notes. First, machine pattern recognition promotes "the rapid and accurate reading of medical scans, slides, skin lesions, the pickup of small polyps during colonoscopy."[22] Second, by using "natural language processing of speech to synthesize notes" AI reduces or even eliminates typing on keyboards, which is "the ultimate source of distraction and dislike in medical encounters."[23] In both cases, the quality of healthcare interactions between healthcare professionals and patients could be fostered. However, liabilities could occur and they "include breaches of privacy and security, hacking, the lack of explainability of most AI algorithms, the potential to worsen inequities, the embedded bias and ethical quandaries."[24]

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Medical Imaging from Adversarial Learning," *European Journal of Nuclear Medicine and Molecular Imaging* (2020), 10.1007/s00259-020-04879-8.

[17]See J.P. Kim et al., "Staging and Quantification of Florbetaben Pet Images Using Machine Learning: Impact of Predicted Regional Cortical Tracer Uptake and Amyloid Stage on Clinical Outcomes," *European Journal of Nuclear Medicine and Molecular Imaging* 47, 8 (2020) 1971-1983.

[18]O'Connor, "How Artificial Intelligence Could Transform Medicine."

[19]See J. Marchant, "Powerful Antibiotics Discovered Using AI," *Nature* (2020), https://www.nature.com/articles/d41586-020-00018-3?utm_sourc; J.M. Stokes et al., "A Deep Learning Approach to Antibiotic Discovery," *Cell* 181, 2 (2020) 475-483.

[20]O'Connor, "How Artificial Intelligence Could Transform Medicine."

[21]O'Connor, "How Artificial Intelligence Could Transform Medicine."

[22]O'Connor, "How Artificial Intelligence Could Transform Medicine."

[23]O'Connor, "How Artificial Intelligence Could Transform Medicine."

[24]O'Connor, "How Artificial Intelligence Could Transform Medicine."

**Artificial Intelligence and Global Public Health**

When we consider the whole planet, international efforts aim at promoting AI in global health,[25] but diversity and inequality exist.[26] As one might expect, in the last decades artificial intelligence has been mostly developed and implemented in high-income countries. In resource-poor settings, while the presence of AI is relatively limited, it has been proposed that AI applications could be used to reduce poverty and deliver public services to improve health outcomes. As examples, "medical expert systems can support physicians in diagnosing patients and choosing treatment plans as is done in high-income countries"[27] and "to predict, model and slow the spread of disease in epidemic situations around the world, including in resource-poor settings."[28]

However, for Mehul Mehta and colleagues, AI could help in promoting health equity globally if three challenges will be addressed. First, the reliability and availability of data regarding low- and middle-income countries should be improved to avoid biases and training errors of the neural networks when the data used concern exclusively high-income settings. Second, AI tools require trained practitioners sufficiently motivated to invest time in acquiring the needed skills. Such necessary condition might be quite challenging in low-income settings struggling with not enough personnel and overwhelming health needs. Third, the health systems should be able to "oversee and manage the rapidly changing technology"[29] and, in particular, the multiple ethical issues related to using AI systems that include "informed consent, privacy, ethics,

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[25]See T. Wiegand et al., "WHO and ITU Establish Benchmarking Process for Artificial Intelligence in Health," *Lancet* 394, 10192 (2019) 9-11. The 2019 *Artificial Intelligence in Global Health* report—funded by the USAID's Center for Innovation and Impact, by the Rockefeller Foundation, and the Bill and Melinda Gates Foundation—discusses 27 cases of AI use in global health care. These cases concern: population health; patient and front-line health worker virtual assistants; and physician clinical decision support. USAID, *Artificial Intelligence in Global Health: Defining a Collective Path Forward*, Washington, D.C.: USAID, 2019.

[26]See National Academies of Sciences Engineering Medicine, *Crossing the Global Quality Chasm: Improving Health Care Worldwide*, Washington, D.C.: The National Academies Press, 2018.

[27]B. Wahl et al., "Artificial Intelligence (AI) and Global Health: How Can AI Contribute to Health in Resource-Poor Settings?," *BMJ Global Health* 3, 4 (2018) e000798, at 3.

[28] Wahl et al., "Artificial Intelligence (AI) and Global Health: How Can AI Contribute to Health in Resource-Poor Settings?," 4.

[29]M.C. Mehta, I.T. Katz, and A.K. Jha, "Transforming Global Health with AI," *New England Journal of Medicine* 382, 9 (2020) 791-793, at 792.

data security, liability, and ignorance of what goes on inside the 'black box' of AI algorithms."[30]

Further health challenges should be considered. During the 2020 global pandemic caused by the coronavirus (called COVID-19), which affected millions of people and that caused hundreds of thousands death, AI, through natural-language processing (NLP) and machine learning algorithms, helped researchers to sort information among the tens of thousands of scientific articles publishing research regarding COVID-19.[31] In particular, Raju Vaishya and colleagues list seven applications of AI in the coronavirus global pandemic.[32] For them, AI could help: first, to detect and diagnose the infection; second, to monitor the treatment; third, to contact tracing individuals who were in contact with infected persons; fourth, to project the number of cases and the expected mortality; fifth, to develop drugs and vaccines; sixth, to reduce the workload of healthcare workers; and, seventh, to prevent further infections by providing real-time data analysis.[33]

## Bioethical Approaches

The previous few examples indicate how artificial intelligence is already present in healthcare. Likely, such presence will increase. After briefly pointing to a few bioethical challenges I turn to an international document and to further bioethical suggestions.

In healthcare, artificial intelligence is already complementing healthcare professionals in their practice by critically examining huge amounts of data. The ethical challenges will be, first, to avoid any bias in introducing and interpreting the data and, second, to compare and integrate accurately any information obtained by AI systems.[34] AI should not replace human interactions in health practice. We cannot ask chatbots, not even Amelia—currently advertised to assess

[30]Mehta, Katz, and Jha, "Transforming Global Health with AI," 792.

[31]See R. Khamsi, "Coronavirus in Context: Scite.Ai Tracks Positive and Negative Citations for COVID-19 Literature," *Nature*, (2020), 10.1038/d41586-020-01324-6; M. Hutson, "Artificial-Intelligence Tools Aim to Tame the Coronavirus Literature," *Nature* (2020), https://www.nature.com/articles/d41586-020-01733-7?utm_source=Nature+Briefing&utm_campaign=691b293313-briefing-dy-20200612&utm_medium=email&utm%E2%80%A6.

[32]See R. Vaishya et al., "Artificial Intelligence (AI) Applications for COVID-19 Pandemic," *Diabetology & Metabolic Syndrome* 14, 4 (2020) 337-339.

[33] See Vaishya et al., "Artificial Intelligence (AI) Applications for COVID-19 Pandemic," 337-339.

[34] See J. Villasenor, "Artificial Intelligence and Bias: Four Key Challenges," Brookings, (2019) https://www.brookings.edu/blog/techtank/2019/01/03/artificial-intelligence-and-bias-four-key-challenges/.

one's risk to be infected by COVID-19[35]—to check our health, make a diagnosis, and recommend a therapy. AI systems should enrich the expertise of healthcare professionals with the unique, but limited contributions that AI systems can offer. Moreover, robots could further complement healthcare practice—for example in complex surgeries. Finally, both in research and clinical labs, the automation that AI systems provide could strengthen the efficiency of automated processes.

**An International Document**

International bodies have reflected on the availability of AI systems and their implementation in the social fabric.[36] I mention one recent document by highlighting its ethical approach.

In 2019, the High-Level Expert Group on AI of the European Commission published the *Ethics Guidelines for Trustworthy Artificial Intelligence*.[37] The European Commission is the executive branch of the European Union and proposes legislation, implements decisions, upholds treaties, and manages the day-to-day business of the European Union.

According to the *Guidelines*, to be trustworthy AI should be: lawful (respecting all laws and regulations), ethical (respecting ethical principles and values), and robust (technically and socially, by considering its social environment).[38]

While the Commission relies on the fundamental rights articulated in the Charter and Treaties of the European Union,[39] in the context of AI systems it articulates four ethical principles that are considered ethical imperatives:[40]

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[35]See https://www.ipsoft.com/covid-19/

[36]As an example, see http://www.oecd.org/going-digital/ai/principles/

[37] See https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai

[38] See https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai. See also High-Level Expert Group on AI, *Ethics Guidelines for Trustworthy Artificial Intelligence*, 3, 5-7.

[39]The fundamental rights for Trustworthy AI are: respect for human dignity; freedom of the individual; respect for democracy, justice, and the rule of law; equality, non-discrimination, and solidarity (including the rights of persons at risk of exclusion); citizens' rights. See High-Level Expert Group on AI, *Ethics Guidelines for Trustworthy Artificial Intelligence*, 11-12.

[40]Hence, AI "practitioners should always strive to adhere to them." High-Level Expert Group on AI, *Ethics Guidelines for Trustworthy Artificial Intelligence*, 11. However, the Commission is aware of possible tensions and conflicts between the principles. For example, between the principle of prevention of harm and the principle of human autonomy: "Consider as an example the use of

1. Respect for human autonomy

2. Prevention of harm (e.g., protection of human dignity as well as mental and physical integrity, with greater attention to vulnerable persons)[41]

3. Fairness (including equality, as well as avoiding bias and discrimination)[42]

4. Explicability (with reference to 'black box' algorithms)[43]

With the exception of the very technical principle of explicability, these principles are inspired by the four principles of biomedical ethics, articulated, since 1979, by Tom Beauchamp and James Childress in their influential *Principles of Biomedical Ethics*, now in its eighth edition.[44]

## Ethical Assessment

Many ethicists and researchers are sufficiently satisfied by these *Guidelines*, particularly when they propose principles aiming at protecting vulnerable citizens and stress the importance of transparency and accountability. However, others are more critical.

In his 2019 review of 21 major ethical guidelines and recommendations regarding AI, Thilo Hagendorff bluntly affirms that "most often" these guidelines do not "have an actual impact on

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AI systems for 'predictive policing,' which may help to reduce crime, but in ways that entail surveillance activities that impinge on individual liberty and privacy." High-Level Expert Group on AI, *Ethics Guidelines for Trustworthy Artificial Intelligence*, 13.

[41]"Vulnerable persons should receive greater attention and be included in the development, deployment and use of AI systems. Particular attention must also be paid to situations where AI systems can cause or exacerbate adverse impacts due to asymmetries of power or information, such as between employers and employees, businesses and consumers or governments and citizens. Preventing harm also entails consideration of the natural environment and all living beings." High-Level Expert Group on AI, *Ethics Guidelines for Trustworthy Artificial Intelligence*, 12.

[42]The principle of fairness "implies a commitment to: ensuring equal and just distribution of both benefits and costs, and ensuring that individuals and groups are free from unfair bias, discrimination and stigmatization" as well as accountability. High-Level Expert Group on AI, *Ethics Guidelines for Trustworthy Artificial Intelligence*, 12.

[43]See High-Level Expert Group on AI, *Ethics Guidelines for Trustworthy Artificial Intelligence*, 12. In artificial intelligence, 'black box' algorithms indicate systems whose inputs and operations are not visible to the user. They are considered impenetrable.

[44]See T.L. Beauchamp and J.F. Childress, *Principles of Biomedical Ethics*, New York: Oxford University Press, 1979; T.L. Beauchamp and J.F. Childress, *Principles of Biomedical Ethics*, 8th ed., New York: Oxford University Press, 2019.

human decision-making in the field of AI and machine learning."[45] In other words, ethical guidelines are present, but ineffective. In their websites, many companies integrate and feature ethical guidelines, reassuring citizens and legislators, and thus protecting their research from undesirable external oversight. Hence, for these companies, a self-chosen tailored ethical commitment, which depends on generic principles, is preferable to any uncontrollable independent ethical assessment. Unbound accountability is scary. Moreover, when ethical violations of these self-chosen guidelines occur, enforcement is limited to "reputational losses in the case of misconduct, or restrictions on memberships in certain professional bodies."[46] These poignant critical remarks invite us to consider what else could inform a more just ethical approach of AI

**Further Ethical Approaches**

In our plural and globalized world, cultural, religious, political, and economic diversity between individuals and countries shape and dominate human interactions. In healthcare practice, is it possible to reflect on AI and to articulate an ethical approach that respects this diversity, integrates multiple approaches, and aims at personal and social well-being?

The ethical tradition, and within it theological bioethics, has something to offer us to address the challenges that characterize ongoing biotechnological developments like AI systems and their implementation. Hence, I integrate the principles highlighted in the international documents that I just discussed with two more elements: first, the focus on the moral agent and on how the moral agent acts (on being and doing); second, the attention given to our context and to what we envision.

First, principles presuppose *moral agents* who discern these principles and apply them. What empowers us as moral agents? Virtues are key dimensions of the personal and social life that guide our being and doing. For example, striving to be just and prudent, and to live justly and prudently, inform our reflection, our choices, and what we do—our practices. Those who are just and prudent, and act justly and prudently, are exemplars we praise and who inspire us. They reinforce our virtuous habits. We can list many other virtues—

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[45]T. Hagendorff, "The Ethics of AI Ethics: An Evaluation of Guidelines," *Minds & Machines* 30 (2020) 99-120, at 1. On machine learning, see also D.S. Char, N.H. Shah, and D. Magnus, "Implementing Machine Learning in Health Care: Addressing Ethical Challenges," *New England Journal of Medicine* 378, 11 (2018) 981-983.

[46]Hagendorff, "The Ethics of AI Ethics: An Evaluation of Guidelines," 99.

from humility to temperance, from fortitude to hope and love, from patience to self-care and courage. Virtues pass the test of cultural diversity and of being historically situated. Being profoundly human, virtues are embodied by everyone: they are universal. Virtues contribute to define who we are as human beings and as moral agents, across any diversity. Within society, in healthcare contexts, virtues inform our discernment, decisions, and actions. Hence, "Virtues help us to act for the right good, at the right time, in the right way."[47]

Reflecting on virtuous moral agents and on virtuous social contexts also invites us to consider the opposite: vices. What are vices that we should identify and address? In reflecting on AI in healthcare, maybe we can list the will to control others, to discriminate, to marginalize, and to exclude by relying on the new opportunities offered to us by AI in healthcare practice.

Second, moral agents do not exist in a vacuum. We are situated in specific *contexts* and in many contexts at the same time. Critical reasoning should help us to examine what are the elements that characterize our context. In each social context, who is proposing to use AI technology? How? For which purpose? For example, in healthcare services, how do we address the changes that AI is introducing? Are we re-training healthcare workers by allowing them to continue to contribute to human labour with their energy, dedication, compassion, expertise, imagination, and creativity? A critical hermeneutic will examine each social context (e.g., patient-physician medical practice, clinics, hospitals, and global public health) by identifying any exclusionary logic.

Within social contexts, including healthcare settings, virtuous moral agents could promote social justice by fostering participation and collaboration of everyone—particularly those who are left out, excluded, and marginalized by avoiding any social inequality, discrimination, and bias that sadly are currently present in our world.

Moreover, technological advances should be at the service of what is good for all citizens, everywhere. Progress in developing artificial intelligence systems should be a further opportunity to search for, and to promote the common good of humankind because "The common good allows the *ultimate realization of individual and social capabilities*. It aims at *individual and collective flourishing* by encompassing all social goods (i.e., spiritual, moral, relational, and

[47] A. Vicini, "Reflecting on CRISPR Gene Editing," *Health Progress* 101, 1 (2020) 5-9, at 8.

material), for all human beings."[48] Moreover, as Lisa Sowle Cahill reminds us, "The global common good, including participation in the good of health care, is an indispensable moral criterion for evaluating policies and politics," whether in the case of health or more broadly in the social fabric.[49]

In conclusion, together with those engaged in promoting health, we should continue to ask that, in light of its current and anticipated applications in healthcare, artificial intelligence should be used in ways that contribute to promote the common good of humankind and of the planet. Moreover, all those engaged in education should strive to educate the present and future generations to make ethically positive contributions in this developing technological field.

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[48] A. Vicini, "Social Justice and the Promotion of the Common Good in Medical Missions to Low-Resourced Countries," *Annals of Global Health* 85, 1 (2019) 83-84, at 84.

[49] L. Sowle Cahill, "Realigning Catholic Priorities: Bioethics and the Common Good," *America* 191, 6 (2004) 11-13, at 12.