

Copyright: The author/s
This work is licensed under a CC-BY 4.0 license
(*) Corresponding author
Peer review method: Double-blind
Original research article
DOI: 10.20544/HORIZONS.1.1.24.P09
Section A



ETHICAL AND LEGAL ASPECTS OF THE USE OF ARTIFICIAL INTELLIGENCE IN HEALTHCARE SYSTEMS: A SUSTAINABLE DEVELOPMENT PERSPECTIVE

Ewelina Mikulska*

Jan Długosz University in Częstochowa

ORCID ID: <https://orcid.org/0000-0003-3327-3016>

Email: e.mikulska@ujd.edu.pl

Abstract

In the face of the dynamic development of artificial intelligence (AI) technologies in healthcare, this article analyzes the ethical and legal aspects of its use in an international context. The aim of the study was to identify key challenges related to the implementation of AI in medicine and to assess existing legal regulations and bioethical standards at the global level. The study employed a method of analyzing scientific literature, international legal acts, and reports from organizations such as the World Health Organization (WHO), the Organization for Economic Cooperation and Development (OECD), and the European Union. An assessment of existing legal regulations and bioethical standards in force at the global level was also conducted. The results indicated significant problems related to the protection of patient data, lack of algorithm transparency, and potential inequalities in access to AI technologies. The legal analysis revealed fragmentation of international regulations and the need for harmonization of provisions to effectively protect patient rights and ensure clinical safety. The conclusions emphasize the necessity of international cooperation in creating uniform legal and ethical frameworks for AI applications in medicine. De legeferenda conclusions are shaped as follows: establishing global standards, promoting ethical programming, and educating medical personnel and patients in the field of AI technologies to maximize benefits and minimize risks associated with its use.

Key words: artificial intelligence, medical law, bioethics, healthcare, medical data protection, patient rights, AI ethics

INTRODUCTION

Nowadays, we can increasingly say that we are living in the future. The visions offered to us by science fiction films from over 30 years ago are becoming our everyday reality. Tablets, holograms, online meetings—these are solutions we eagerly embrace. The last few years of technological development have brought us another useful tool: artificial intelligence.

Artificial intelligence (AI) has become one of the most groundbreaking technological achievements of the 21st century, influencing almost every aspect of modern life. In the healthcare sector, we observe particularly dynamic development of AI applications, which promises to revolutionize the way diseases are diagnosed, treated, and prevented. From

analyzing medical images using machine learning algorithms, through predicting epidemics based on big data, to personalized medicine based on genome analysis—AI opens new perspectives for improving the quality and efficiency of healthcare.

The growing role of AI in medicine is driven by several key factors. Firstly, the global aging of societies and the increase in chronic diseases raise the demand for innovative medical solutions. Secondly, the enormous amount of data generated in the patient care process requires advanced analytical tools for effective utilization. Thirdly, advances in computational technologies and access to cloud computing power enable the development of increasingly advanced AI algorithms.

However, integrating AI into healthcare also raises a number of significant challenges. Issues such as privacy and security of patient data, transparency of algorithms, responsibility for decisions made by AI systems, and potential biases and discrimination resulting from errors in training data are becoming increasingly pressing. Moreover, the lack of uniform international legal regulations and ethical standards complicates the implementation of these technologies on a global scale.

In light of these challenges, an in-depth analysis of the ethical and legal aspects of AI use in healthcare is necessary. Understanding these issues is crucial to ensure that the development and implementation of AI occur responsibly, respecting patient rights and in accordance with bioethical principles. This article aims to present these issues, with particular emphasis on international law, and to indicate directions for future regulatory and practical actions.

ARTIFICIAL INTELLIGENCE IN HEALTHCARE

Definition of AI and It's Applications in Medicine

Artificial intelligence (AI) is a field of science and technology focused on creating systems and computer programs capable of performing tasks that require human intelligence, such as learning, reasoning, pattern recognition, and decision-making¹. According to McCarthy, one of the pioneers of AI, it is the science and engineering of making intelligent machines².

In the context of medicine, AI refers to the application of algorithms and computational models to analyze complex medical data, support diagnosis, predict disease progression, and personalize therapy.³ Kaplan and Haenlein define AI as systems capable of correctly interpreting external data, learning from that data, and using the acquired knowledge to achieve specific goals through flexible adaptation.⁴

A key element of AI is machine learning, which allows systems to self-improve based on experience without explicit programming.⁵ In medicine, machine learning is used in analyzing radiological images, detecting patterns in genetic data, and predicting patients' responses to specific therapies.⁶

¹ Nilsson, N.J., 2010, *The Quest for Artificial Intelligence: A History of Ideas and Achievements*, Cambridge University Press, p. 81.

² McCarthy, J. 2007, *What is Artificial Intelligence*, online
<http://jmc.stanford.edu/articles/whatisai/whatisai.pdf>

³ Shortliffe, E. H., Sepulveda, M. J., 2018, *Clinical Decision Support in the Era of Artificial Intelligence*, JAMA, 320(21), 2199-2200.

⁴ Kaplan, A., Haenlein, M., 2019, *Siri, Siri, in my Hand: Who's the Fairest in the Land? On the Interpretations, Illustrations and Implications of Artificial Intelligence*, Business Horizons, 62(1), 15-25.

⁵ Mitchell, T. M., 1997, *Machine Learning*, McGraw-Hill.

⁶ Esteva, A., Robicquet, A., Ramsundar B., 2019, *A Guide to Deep Learning in Healthcare*, Nature Medicine, 25, 24-29.

Definitions of AI increasingly include ethical and social aspects. The European Group on Ethics in Science and New Technologies describes AI as systems capable of autonomous action in complex environments, which can have a significant impact on people and society, requiring ethical and legal responsibility.⁷ In this context, it is important that the development of AI in medicine aligns with bioethical principles and respects patient rights.

Current Technological Trends

Considering the enormous potential of technologies like artificial intelligence, the limits of its application have yet to be discovered. Observing its vast array of uses, one might venture to say that AI is not only a helpful tool in daily work but also the future of medicine. Below are some currently employed methods leveraging its capabilities:

1. **Deep Learning and Medical Image Analysis:** Deep learning has revolutionized the analysis of medical images. These algorithms can automatically detect and classify pathological changes on X-rays, computed tomography, or magnetic resonance images with accuracy comparable to medical experts.⁸ An example is the detection of cancerous changes in the lungs or diabetic retinopathy.
2. **Personalized Medicine and Genetic Data Analysis:** AI aids in personalizing therapy by conducting complex and time-consuming analyses of patients' genetic and molecular data. Machine learning algorithms help identify genetic markers responsible for reactions to specific drugs, enabling therapy to be tailored to individual patient needs.⁹
3. **Telemedicine and Remote Monitoring:** The development of IoT devices and wearable technologies allows continuous monitoring of patients' vital parameters. AI analyzes real-time data, detecting abnormalities and alerting medical staff in cases of threats to life or health.¹⁰
4. **Chatbots and Virtual Assistants:** Despite occasional opinions on the low usefulness of chatbots, in healthcare, AI-based chatbots facilitate communication between patients and providers. They can provide information, schedule appointments, or monitor symptoms, increasing the accessibility of medical services.¹¹
5. **Optimization of Clinical Processes:** AI is applied to optimize management in large medical facilities as well as smaller clinics and offices. Data analysis allows for better resource planning, supply chain management, and predicting ward occupancy.
6. **Development of Robotics in Surgery:** Although it seems drawn directly from science fiction, dynamic development—or even revolution—in this area is the near future of medicine. AI-assisted surgical robots enable precise procedures with minimal invasiveness. This results in faster patient recovery and reduced risk of complications.¹²

⁷European Group on Ethics in Science and New Technologies, 2018, *Statement on Artificial Intelligence, Robotics and Autonomous Systems*, online <https://op.europa.eu/en/publication-detail/-/publication/dfebe62e-4ce9-11e8-be1d-01aa75ed71a1>

⁸Litjens, G., Kooi, T., Bejnordi, B. E., 2017, *A survey on deep learning in medical image analysis*, Medical Image Analysis, 42, 60-88.

⁹Topol, E. J., 2019, *High-performance medicine: the convergence of human and artificial intelligence*, Nature Medicine, 25(1), 44-56.

¹⁰Dunn, J., Runge, R., Snyder, M., 2018, *Wearables and the medical revolution*, Personalized Medicine, 15(5), 429-448, online: <https://www.tandfonline.com/doi/full/10.2217/pme-2018-0044#d1e195>

¹¹Bibault, J.-E., Chaix, B., Nectoux, P., 2019, *Healthcare ex Machina: Are conversational agents ready for prime time in oncology?*, Clinical and Translational Radiation Oncology, 16, 55-59.

¹²Yang, G.-Z., Nelson, B. J., Murphy R. R., 2020, *Comating COVID-19 – The role of robotics in managing public health and infectious diseases*, Science Robotics, 5(40), online: <https://www.science.org/doi/epdf/10.1126/scirobotics.abb5589>

7. **Combating Epidemics:** AI can model the spread of viruses, predict disease outbreaks, and assess the effectiveness of interventions to protect public health.¹³
8. **Data Integration:** AI enables the integration and analysis of data from various sources, such as electronic medical records, laboratory data, or patient information. This facilitates a comprehensive approach to care and more informed clinical decisions, paying attention to every detail and matching appropriate solutions.¹⁴
9. **Automation of Laboratory Diagnostics:** AI automates and accelerates diagnostic processes in medical laboratories, increasing efficiency and accuracy while minimizing the risk of incorrect results.¹⁵

The above are just some examples of AI applications in healthcare. Many other potential solutions are in planning, testing, or even purely conceptual stages. What recently seemed impossible is now in use, suggesting that in the near future, medicine may face many bioethical dilemmas.

ETHICAL ASPECTS OF USING AI IN HEALTHCARE

The development of artificial intelligence (AI), particularly in medicine, opens up new diagnostic and therapeutic possibilities while confronting society with a series of ethical dilemmas. Introducing AI into clinical practice requires not only assessing its effectiveness and safety but also reflecting on its impact on patient rights, principles of social justice, and individual autonomy. Technology capable of analyzing vast amounts of data and making decisions may disrupt traditional relationships between patient and physician and raise questions about responsibility for potential errors. In the face of these challenges, it is necessary to examine how to ensure the ethical use of AI in healthcare, respecting fundamental bioethical values and norms.

Privacy and Confidentiality of Patient Data

Artificial intelligence operating on datasets composed of patients' medical information is a ticking time bomb. Medical data is particularly sensitive, and its protection is crucial for maintaining patient trust in the healthcare system. AI systems require large datasets to train and refine algorithms. Collecting this data often includes personal and medical information, posing risks of privacy breaches.¹⁶

AI-based systems are susceptible to cyberattacks, which can lead to theft or manipulation of patient data.¹⁷ Data breaches can have severe consequences for patients, including discrimination, loss of trust, or financial harm. One of the most critical issues is properly securing access to collected data and ensuring its correct storage to prevent accidental

¹³ Bullock, J., Luccioni, A., Pham, K. H., 2020, *Mapping the landscape of Artificial Intelligence applications against COVID-19*, Journal of Artificial Intelligence Research, 69, 807-845.

¹⁴ Esteva, A., Robicquet, A., Ramsundar, B., 2019, *A guide to deep learning in healthcare*, Nature Medicine, 25(1), 24-29.

¹⁵ Sufyan, M., Shokat, Z., Ashfaq, U. A., 2023, *Artificial intelligence in cancer diagnosis and therapy: Current status and future perspective*, Computers in Biology and Medicine, vol 165, online: <https://www.sciencedirect.com/science/article/pii/S0010482523008211>

¹⁶ Prince, W. N., Cohen, I. G., 2019, *Privacy in the age of medical big data*, Nature Medicine, 25(1), 37-43.

¹⁷ Pool, J., Akhlaghpour, S., Fatehi, F., Burton-Jones, A., 2024, *A systematic analysis of failures in protecting personal health data: A scoping review*, International Journal of Information Management, vol. 72, online: <https://www.sciencedirect.com/science/article/pii/S0268401223001007>

deletion, which in extreme cases could threaten patient health or life. Inadequate security can lead to unauthorized access or use of data for purposes inconsistent with their original intent.

Another significant issue involves problems related to collecting and storing data and using it to feed AI systems for learning purposes. To protect patient privacy, techniques like anonymization and pseudonymization are often employed. **Anonymization** involves removing or modifying personal data so that identifying the individual becomes impossible or extremely difficult. Anonymization is one of the most commonly used methods of personal data protection, particularly popular in Europe in the early 21st century. In the United States during the same period, the term "coding" was used in a similar context. According to the **ISO 29100:2011** standard, anonymization is a process involving the irreversible transformation of information identifying a person. The goal is to prevent identification of that person, both directly and indirectly, by the data controller or in cooperation with other entities. This process ensures that data cannot be attributed to a specific natural person, even using additional information or advanced analytical methods. Thus, individual privacy is protected, and the risk of personal data breaches is minimized. Anonymization is crucial when using large datasets in AI, where data is necessary for training models but must be processed in compliance with data protection regulations.¹⁸

Pseudonymization is a concept introduced into legal science through the **Regulation (EU) 2016/679** of the European Parliament and of the Council of 27 April 2016 on data protection (GDPR).¹⁹ Article 4 point 5 states: "'pseudonymization' means the processing of personal data in such a manner that the data can no longer be attributed to a specific data subject without the use of additional information, provided that such additional information is kept separately and is subject to technical and organizational measures".

Studies indicate that even anonymized data can be re-identified using advanced analytical methods.²⁰ The development of sophisticated analytical techniques and the availability of large datasets increase the possibilities of de-anonymizing information.²¹ This raises questions about the effectiveness of current data protection practices in the era of big data and AI. For example, Sweeney demonstrated that 87% of the U.S. population could be identified based on a combination of zip code, date of birth, and gender.²² In the medical context, this risk is particularly high due to the uniqueness of clinical data.

To protect patients from AI errors and data leaks, increasingly advanced protection methods are being introduced. One proposed solution is **differential privacy**, which provides mathematical guarantees of privacy protection by adding controlled noise to data or analysis results.²³ This technique allows obtaining valuable statistical information without revealing individual patient data.

¹⁸Maricniak, B., Strapagiel, D., Topolski, P., *Anonimizacja w dobie wielkich danych – sytuacja biobanków w kontekście RODO*, *Studia Iuridica*, LXXII, p. 75.

¹⁹Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation) (Journal of Laws EU. L. of 2016, No. 119, page 1, as amended).

²⁰Rocher, L., Hendrickx, J. M., Montjoye, Y. -A., 2019, *Estimating the success of re-identifications in incomplete datasets using generative models*, *Nature Communications*, 10, online: <https://www.nature.com/articles/s41467-019-10933-3>

²¹ Ohm, P., 2010, *Broken Promises of Privacy: Responding to the Surprising Failure of Anonymization*, *UCLA Law Review*, 57(6), 1701-1777.

²² Sweeney, L., 2000, *Simple Demographics Often Identify People Uniquely*, Carnegie Mellon University, Data Privacy Working Paper, 3.

²³Dwork, C., & Roth, A., 2014, *The Algorithmic Foundations of Differential Privacy*. *Foundations and Trends in Theoretical Computer Science*, 9(3–4), 211-407.

Another approach is federated learning, which enables training AI models without centralizing data. Data remains on local devices, and only model updates are aggregated, minimizing the risk of privacy breaches.²⁴

Justice and Access to AI Technologies

The use of artificial intelligence (AI) in healthcare promises significant improvements in the quality of medical care but also raises questions about justice and equality in access to these advanced technologies. Gaps between algorithmic outputs and human ethical perceptions can have serious consequences for individuals and entire societies.²⁵ There is a risk that the benefits of AI will be unevenly distributed, potentially deepening existing health inequalities between different social groups and regions.²⁶

In developing countries, access to modern medical technologies is often limited due to a lack of infrastructure and financial resources. The World Health Organization (WHO) pays particular attention to the unjust distribution of technology. Topics such as e-health, telemedicine, or large databases should be considered, accounting for all difficulties in access and possibilities of infrastructural development.²⁷ Neglect in this area can lead to situations where only wealthier societies fully benefit from AI achievements in medicine. This undoubtedly contradicts the principle of justice in healthcare.

Moreover, even in developed countries, there may be disparities in access to AI between urban and rural areas, where technological infrastructure is less developed. Such disparities can result in poorer health outcomes for marginalized populations. Currently, there is no internationally agreed strategy for measuring and analyzing patient harm, hindering the monitoring of safety improvement programs. In low- and middle-income countries (LMICs), significant data gaps lead to probable underestimation of the actual burden of patient harm; investments in high-quality medical records and better research standards are necessary. Transitioning from a "blame culture" to a "just culture" and implementing coordinated, systematic measurement methods are key to effectively preventing future adverse events.²⁸

The principle of justice in bioethics requires that all patients have equal access to healthcare and medical innovations.²⁹ To counteract inequalities, policies supporting technology transfer and capacity building in lower-income countries are proposed, along with adhering to recommendations on digital interventions for health system strengthening. It's crucial to consider population diversity in the algorithm design process to avoid biases and discrimination.³⁰

LEGAL RECOMMENDATIONS ON ARTIFICIAL INTELLIGENCE AT THE INTERNATIONAL LEVEL

²⁴Konečný, J., McMahan, H. B., Ramage, D., & Richtárik, P., 2016, *Federated Optimization: Distributed Machine Learning for On-Device Intelligence*, online: <https://arxiv.org/pdf/1610.02527>

²⁵Mittelstadt, B. D., Allo, P., Taddeo, M., Wachter, S., & Floridi, L., 2016, *The ethics of algorithms: Mapping the debate*. Big Data & Society, 3(2), 1–21.

²⁶Vayena, E., Blasimme, A., & Cohen, I. G., 2018, *Machine learning in medicine: Addressing ethical challenges*. PLoS Medicine, 15(11).

²⁷World Health Organization, 2016, *Global diffusion of eHealth: Making universal health coverage achievable*, online: <https://iris.who.int/bitstream/handle/10665/252529/9789241511780-eng.pdf?sequence=1&isAllowed=y>

²⁸World Health Organization, 2024, *Global patient safety report*, online: <https://www.who.int/publications/i/item/9789240095458>

²⁹Beauchamp, T. L., & Childress, J. F., 2001, *Principles of Biomedical Ethics*, Oxford University Press, p. 230.

³⁰Obermeyer, Z., Powers, B., Vogeli, C., & Mullainathan, S., 2019, *Dissecting racial bias in an algorithm used to manage the health of populations*, Science, 366(6464), 447–453.

UNESCO

In 2021, UNESCO developed a report titled "**Recommendation on the Ethics of Artificial Intelligence**", establishing global ethical frameworks for the development and use of artificial intelligence (AI). The recommendation emphasizes the necessity of protecting human rights as a central element in AI implementation, paying particular attention to privacy and data confidentiality as fundamental rights that must be respected.

In the context of medicine, the report accentuates the need for ethical design and use of AI in ways that respect human dignity, patient autonomy, and their right to informed consent. UNESCO calls for ensuring transparency of AI algorithms, which is crucial for building trust between patients and AI-based healthcare systems.

The report also highlights the risk of algorithmic biases and potential discrimination resulting from errors in training data. Additionally, the document underscores the importance of international cooperation in creating coherent legal regulations and ethical standards. It points to the need for harmonizing regulations to effectively manage AI development on a global scale, particularly in healthcare, where data and technologies often cross national borders.³¹

OECD

The **Organization for Economic Cooperation and Development (OECD)** in 2019 adopted a set of five principles aimed at promoting responsible and trustworthy use of artificial intelligence (AI). These principles emphasize the importance of respecting human rights, the rule of law, democratic values, and diversity. Key postulates include ensuring that AI systems bring social benefits and are designed to promote inclusion and sustainable development. The OECD highlights the need for transparency and explainability of AI algorithms so users can understand their operation and decisions. Furthermore, the principles emphasize the responsibility of AI creators and users for its operation and the necessity of establishing mechanisms of accountability and oversight over AI systems.³²

European Commission

The **White Paper** published by the European Commission in February 2020 presents the European Union's strategy for promoting the development and implementation of artificial intelligence (AI) in a way that ensures both technological excellence and social trust.³³ The document emphasizes the importance of two key pillars: an **ecosystem of excellence** and an **ecosystem of trust**. The focus is on increasing investments in AI research and development and supporting education and training in this field, as well as creating appropriate regulatory frameworks to ensure that AI development and use align with EU values and fundamental rights.

The White Paper also underscores the importance of international cooperation regarding AI standards and norms and the need to ensure interoperability and compliance with

³¹UNESCO, 2021, *Recommendation on the Ethics of Artificial Intelligence*, online: <https://unesdoc.unesco.org/ark:/48223/pf0000380455>

³² <https://www.oecd.org/en/topics/ai-principles.html>

³³White Paper on Artificial Intelligence - A European approach to excellence and trust, https://commission.europa.eu/document/download/d2ec4039-c5be-423a-81ef-b9e44e79825b_pl?filename=commission-white-paper-artificial-intelligence-feb2020_pl.pdf

regulations of other jurisdictions. The Commission highlighted that healthcare is one of the sectors with the highest risk in the context of AI applications, due to the potential impact on patients' lives and health and the necessity of processing sensitive personal data.

United Nations

At the international level, numerous initiatives aim to promote new technologies, including the development of artificial intelligence. Noteworthy is the **"AI for Good"** initiative organized by the **International Telecommunication Union (ITU)**, a specialized agency of the United Nations responsible for issues related to information and communication technologies. Launched in 2017, the initiative aims to accelerate the development and implementation of AI-based solutions to address global challenges, particularly those related to the United Nations Sustainable Development Goals (SDGs).³⁴

Beyond various research fields, the initiative also focuses on healthcare, promoting ethical and responsible AI applications to improve medical diagnostics, patient care, and disease prevention. It simultaneously emphasizes the importance of privacy protection, data security, and ensuring equal access to technological innovations.

The above represent some of the many legal acts and initiatives taking place globally. Issues related to the effective use of AI continue to gain prominence.

CONCLUSIONS

The development of artificial intelligence (AI) in healthcare brings the promise of revolutionary changes in diagnosing, treating, and preventing diseases. Its applications—from analyzing medical images to personalized therapy and remote patient monitoring—highlight the enormous potential of this technology in improving the quality and efficiency of healthcare. However, introducing AI into medicine brings significant ethical and legal challenges that require in-depth analysis and attention.

Conclusions from the analysis indicate that the key to effective and ethical use of AI in healthcare is balancing technological innovations with respect for patient rights and bioethical principles. It is necessary to further develop international standards, invest in data infrastructure, and educate both medical personnel and patients about AI technologies.

Given the rapid technological progress and changing social and legal realities, it is impossible to exhaust this topic in a single article. Continuous monitoring, research, and international discourse are required. Only through coordinated actions and open dialogue will it be possible to fully harness the potential of AI in medicine while ensuring the protection of patient rights and compliance with ethical principles.

BIBLIOGRAPHY

1. Beauchamp, T. L., and Childress, J. F. 2001. *Principles of Biomedical Ethics*. Oxford: Oxford University Press.
2. Bibault, J.-E., Chaix, B., and Nectoux, P. 2019. "Healthcare ex Machina: Are Conversational Agents Ready for Prime Time in Oncology?" *Clinical and Translational Radiation Oncology* 16: 55–59.

³⁴<https://aiforgood.itu.int/>

3. Biała Księga w sprawie sztucznej inteligencji: Europejskie podejście do doskonałości i zaufania [*White Paper on Artificial Intelligence: A European Approach to Excellence and Trust*]. Available at: https://commission.europa.eu/document/download/d2ec4039-c5be-423a-81ef-b9e44e79825b_pl?filename=commission-white-paper-artificial-intelligence-feb2020_pl.pdf (Accessed: 26.11.2024)
4. Bullock, J., Luccioni, A., and Pham, K. H. 2020. "Mapping the Landscape of Artificial Intelligence Applications Against COVID-19." *Journal of Artificial Intelligence Research* 69: 807–845.
5. Dunn, J., Runge, R., and Snyder, M. 2018. "Wearables and the Medical Revolution." *Personalized Medicine* 15(5): 429–448.
6. Dwork, C., and Roth, A. 2014. "The Algorithmic Foundations of Differential Privacy." *Foundations and Trends in Theoretical Computer Science* 9(3–4): 211–407.
7. Esteva, A., Robicquet, A., and Ramsundar, B. 2019. "A Guide to Deep Learning in Healthcare." *Nature Medicine* 25: 24–29.
8. European Group on Ethics in Science and New Technologies (EGE). 2018. *Statement on Artificial Intelligence, Robotics and Autonomous Systems*. Available at: <https://op.europa.eu/en/publication-detail/-/publication/dfebe62e-4ce9-11e8-be1d-01aa75ed71a1> (Accessed: 26.11.2024)
9. Kaplan, A., and Haenlein, M. 2019. "Siri, Siri, in My Hand: Who's the Fairest in the Land? On the Interpretations, Illustrations and Implications of Artificial Intelligence." *Business Horizons* 62(1): 15–25.
10. Konečný, J., McMahan, H. B., Ramage, D., and Richtárik, P. 2016. "Federated Optimization: Distributed Machine Learning for On-Device Intelligence." Available at: <https://arxiv.org/pdf/1610.02527> (Accessed: 26.11.2024)
11. Litjens, G., Kooi, T., and Bejnordi, B. E. 2017. "A Survey on Deep Learning in Medical Image Analysis." *Medical Image Analysis* 42: 60–88.
12. Maricniak, B., Strapagiel, D., and Topolski, P. [n.d.]. "Anonimizacja w dobie wielkich danych – sytuacja biobanków w kontekście RODO" [*Anonymization in the Era of Big Data – The Situation of Biobanks in the Context of GDPR*]. *Studia Iuridica* LXXII: 75.
13. McCarthy, J. 2007. "What Is Artificial Intelligence?" Available at: <http://jmc.stanford.edu/articles/whatisai/whatisai.pdf> (Accessed: 26.11.2024)
14. Mittelstadt, B. D., Allo, P., Taddeo, M., Wachter, S., and Floridi, L. 2016. "The Ethics of Algorithms: Mapping the Debate." *Big Data & Society* 3(2): 1–21.
15. Mitchell, T. M. 1997. *Machine Learning*. New York: McGraw-Hill.
16. Narayanan, A., and Shmatikov, V. 2008. "Robust De-anonymization of Large Sparse Datasets." *2008 IEEE Symposium on Security and Privacy*: 111–125.
17. Nilsson, N. J. 2010. *The Quest for Artificial Intelligence: A History of Ideas and Achievements*. Cambridge: Cambridge University Press.
18. Obermeyer, Z., Powers, B., Vogeli, C., and Mullainathan, S. 2019. "Dissecting Racial Bias in an Algorithm Used to Manage the Health of Populations." *Science* 366(6464): 447–453.
19. Ohm, P. 2010. "Broken Promises of Privacy: Responding to the Surprising Failure of Anonymization." *UCLA Law Review* 57(6): 1701–1777.
20. Organization for Economic Co-operation and Development (OECD). 2019. *AI Principles*. Available at: <https://www.oecd.org/en/topics/ai-principles.html> (Accessed: 26.11.2024)
21. Pool, J., Akhlaghpour, S., Fatehi, F., and Burton-Jones, A. 2024. "A Systematic Analysis of Failures in Protecting Personal Health Data: A Scoping Review." *International Journal of Information Management* 72.
22. Prince, W. N., and Cohen, I. G. 2019. "Privacy in the Age of Medical Big Data." *Nature Medicine* 25(1): 37–43.
23. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the Protection of Natural Persons with Regard to the Processing of Personal Data and on the Free Movement of Such Data, and Repealing Directive 95/46/EC (General Data Protection Regulation). *Journal of Laws EU L.* of 2016, No. 119, p. 1 (as amended).

24. Rocher, L., Hendrickx, J. M., and Montjoye, Y.-A. 2019. "Estimating the Success of Re-identifications in Incomplete Datasets Using Generative Models." *Nature Communications* 10. Available at: <https://www.nature.com/articles/s41467-019-10933-3> (Accessed: 26.11.2024)
25. Sachs, J. D. 2012. "From Millennium Development Goals to Sustainable Development Goals." *The Lancet* 379(9832): 2206–2211.
26. Shortliffe, E. H., and Sepulveda, M. J. 2018. "Clinical Decision Support in the Era of Artificial Intelligence." *JAMA* 320(21): 2199–2200.
27. Sufyan, M., Shokat, Z., and Ashfaq, U. A. 2023. "Artificial Intelligence in Cancer Diagnosis and Therapy: Current Status and Future Perspective." *Computers in Biology and Medicine* 165.
28. Sweeney, L. 2000. "Simple Demographics Often Identify People Uniquely." Carnegie Mellon University, *Data Privacy Working Paper* 3.
29. Topol, E. 2019. *Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again*. New York: Basic Books.
(Corrected "Intelligence" spelling.)
30. Topol, E. J. 2019. "High-performance Medicine: The Convergence of Human and Artificial Intelligence." *Nature Medicine* 25(1): 44–56.
31. UNESCO. 2021. *Recommendation on the Ethics of Artificial Intelligence*. Available at: <https://unesdoc.unesco.org/ark:/48223/pf0000380455> (Accessed: 26.11.2024)
32. Vayena, E., Blasimme, A., and Cohen, I. G. 2018. "Machine Learning in Medicine: Addressing Ethical Challenges." *PLoS Medicine* 15(11).
33. World Health Organization. 2016. *Global Diffusion of eHealth: Making Universal Health Coverage Achievable*. Available at: <https://iris.who.int/bitstream/handle/10665/252529/9789241511780-eng.pdf?sequence=1&isAllowed=y> (Accessed: 26.11.2024)
34. World Health Organization. 2019. *WHO Guideline: Recommendations on Digital Interventions for Health System Strengthening*. Available at: <https://iris.who.int/handle/10665/311941> (Accessed: 26.11.2024)
35. World Health Organization. 2024. *Global Patient Safety Report*. Available at: <https://www.who.int/publications/i/item/9789240095458> (Accessed: 26.11.2024)
36. Yang, G.-Z., Nelson, B. J., and Murphy, R. R. 2020. "Comating COVID-19 – The Role of Robotics in Managing Public Health and Infectious Diseases." *Science Robotics* 5(40).