

Call for papers: "Intelligenza
Artificiale: prospettive bioetiche,
bio giuridiche e sociali"

GenGPT can understand your
DNA, but can it handle your
decisions?

*GenGPT può interpretare il tuo
DNA, ma come se la cava con la
comprensione delle tue scelte?*

TOMMASO ROPELATO
tommaso.ropelato@unito.it

AFFILIAZIONE
Fondazione Bruno Kessler - Centro per le
Scienze Religiose (ISR)
Università degli studi di Torino

SOMMARIO

L'intelligenza artificiale (IA) sta rivoluzionando il settore medico, offrendo strumenti innovativi che potrebbero trasformare vari aspetti della sanità. Tra questi, spiccano per versatilità e popolarità i Large Language Models (LLMs) come ChatGPT. Questo articolo propone l'applicazione di una specifica variante allenata su database scientifici e specialistici, GenGPT, al settore del counseling genetico nel contesto riproduttivo. Nonostante il potenziale di questo strumento nel migliorare l'efficienza e il supporto ai pazienti emergono preoccupazioni riguardo alla loro capacità di gestire decisioni complesse e delicate, come quelle legate ai test genetici prenatali e preimpianto. Soffermandosi su due elementi spesso sottovalutati dalla letteratura tradizionale sul consenso informato, vale a dire i concetti di affidabilità e trasparenza dei valori, l'articolo conclude che, sebbene questi strumenti possono essere di supporto nella pratica medica, essi non possono sostituire completamente il giudizio umano e l'interazione personalizzata necessari in ambiti così sensibili.

PAROLE CHIAVE

Counseling genetico
Consenso informato
Trasparenza dei valori
Test genetici riproduttivi
Autonomia Riproduttiva

ABSTRACT

Artificial intelligence (AI) is revolutionizing healthcare with innovative tools that promise to transform various aspects of the field. Among these, Large Language Models (LLMs) like ChatGPT stand out for their versatility and popularity. This paper explores the application of GenGPT, a variant specifically trained on scientific and specialized databases, to genetic counseling in the reproductive context. Despite its potential to enhance efficiency and patient support, concerns arise about its ability to handle complex and sensitive decisions, such as those involving prenatal and preimplantation genetic testing. By focusing on often-overlooked elements in informed consent literature—namely, trustworthiness and value transparency—the paper concludes that while such tools can support healthcare, they cannot fully replace the human judgment and personalized interaction essential in such sensitive areas.

KEYWORDS

*Genetic Counseling
Informed Consent
Value Transparency
Reproductive Genetic Testing
Reproductive Autonomy*

MedGPT
can understand
your DNA

Call for papers:
"Intelligenza
Artificiale:
prospettive
bioetiche,
biogiuridiche e
sociali"

DOI: 10.53267/20240105



MedGPT
can understand
your DNA

Call for papers:
"Intelligenza
Artificiale:
prospettive
bioetiche,
biogiuridiche e
sociali"

1. INTRODUCTION

Artificial intelligence (AI) is rapidly transforming the medical field, introducing groundbreaking tools that are reshaping various aspects of healthcare. Among these innovations, generative large language models (LLMs) like ChatGPT are gaining increasing popularity. These models can engage in conversational exchanges and produce diverse textual content, ranging from emails and articles to computer code, sparking considerable excitement about their potential applications in the clinical setting¹. It is possible to assume, as confirmed by ChatGPT itself², that they could soon be used to facilitate the documentation of patient reports, improve diagnostic accuracy³, and assist in various clinical care⁴. However, there are also important concerns regarding hallucinations, biases⁵, stereotype fabrication⁶, and risks to patient privacy⁷.

Yet, it is crucial to recognize that current models are not specifically designed for healthcare use. The following paper explores the potential application of a variant specifically designed for medical applications, such as the recently proposed BioGPT⁸, a domain-specific generative pre-trained transformer language model for biomedical text generation and mining⁹, in one of the most emerging, high-information and ethically complex field: genetic counseling in the procreative context. Indeed, one of the most promising application for LLMs in terms of streamlining healthcare resources and optimizing hospital human capital is patient support¹⁰. However, regarding this specific use case, as already highlighted in some papers on the use of ChatGPT in psychotherapy¹¹, experiments show that while ChatGPT is a good causal interpreter¹², it is not a good causal reasoner¹³. This raises significant concerns about its ability to effectively assist in making informed decisions, particularly in critical and sensitive areas such as genome-driven reproductive decision-making.

2. LLMs AND DATA-DRIVEN MEDICINE

The majority of us have now encountered ChatGPT, witnessing firsthand its remarkable ability to analyze, process, and reinterpret vast amounts of data with unprecedented speed and precision. Consequently, LLMs hold great potential within the increasingly data-driven medical field¹⁴. Their applications range from

identifying research priorities to supporting healthcare professionals in clinical and laboratory diagnostics. Additionally, they can assist medical students, doctors, nurses, and other healthcare providers in staying updated on advancements in their fields. One of the most peculiar and critical application of LLMs in medicine could be their role in developing virtual assistants aimed at helping patients manage their health¹⁵. Such applications have the potential not only to offer cost-effective, scalable, and inclusive solutions but also to drive healthcare toward more personalized digital health ecosystems. These advancements are particularly crucial in clinical genomics, where the effective governance, interpretation, and communication of extensive data from genome sequencing and population-level studies pose significant challenges.

Therefore, this paper delves into the potential application of a specialized variant of ChatGPT, which we will refer to as GenGPT, trained specifically on medical specialized literature, within the domain of genetic and genomic screening and testing (GSTs)¹⁶. While ChatGPT has been already trialed in medical education, primarily for manuscript writing and standardized exams¹⁷, and garnered interest for streamlining workflows, and educating patients in various specialties, including ophthalmology¹⁸, radiology¹⁹, rheumatology²⁰, and cardiology²¹, assessments regarding its utility in clinical genetics remain limited. A recent study²², published in the "American Journal of Medical Genetics", surveyed 118 genetic counselors (GCs) in North America about the integration of ChatGPT into their profession. Among the 92 GCs who spend some of their time in a clinical role, 29.3% (27) report using it for some aspect of their work. The most commonly stated use is drafting clinical documentation including consult notes and result letters. More specifically, GCs said that ChatGPT is helpful in providing patient-friendly language suggestions, generating text for informational files, and finding support resources. Of the 35 GCs who spend some part of their time doing research, 37.1% (13) say that the most commonly use of ChatGPT in this setting is to help draft a literature review by pulling citations and references and summarizing papers. Other uses included assisting with data analysis by providing guidance on type of hypothesis testing, writing code for statistical software, and developing themes for interview codebook. Many of these participants also

use ChatGPT to write research documents such as grant applications, IRB protocols, survey questions and interview scripts. More generally, the ability to save time on administrative tasks was the most frequently reported benefit (74; 62.7%), which could help alleviate burnout, an issue exacerbated by the significant time GCs spend on non-clinical duties²³.

We seek to extend the current discussion by questioning whether a tool like GenGPT could enable GCs and clinical professionals to delegate more than just administrative tasks to AI. By identifying four levels of medical services that AI tools could potentially provide²⁴, namely, 'information' (e.g., using voice assistants, chatbots, and dialogue-based applications to initiate self-care guidance), 'assistance' (e.g., setting reminders for medication or self-therapy), 'assessment' (e.g., identification, detection, prediction with digital biomarkers, and management), and 'support' (prescribing, substituting, or supplementing medication and therapy tools), LLMs have the potential to significantly expand the range of virtual assistant applications toward the 'assessment' and 'support' levels. Focusing on this paradigm shift allows us to underscore several traditionally overlooked issues regarding the use of LLMs in clinical medicine. Alongside the well-known ethical and legal considerations associated with LLMs, such as avoiding biases and hallucinations, and preventing misinformation, which could potentially be mitigated by developing a model specifically pre-trained and designed for the proposed tasks, this paper addresses a central concern specific to GenGPT: its capability to establish meaningful relationships with prospective parents to support informed and consensual reproductive choices.

3. WHAT SHOULD I CONSENT TO, AND WHAT INFORMATION SHOULD GUIDE MY DECISION?

In medicine and research, consent occurs when A (who could be a patient or research participant) agrees to B (who could be a physician or researcher) performing an action on A (such as conducting a medical test). Consent is considered informed when A has been provided with relevant information and possesses sufficient decision-making capacity. Consent is deemed fully informed when a capacitated (or competent) patient or research participant, having received complete disclosures and comprehended all information

disclosed, voluntarily agrees to treatment or participation²⁵.

Achieving this standard is challenging, if not impossible, in the context of GSTs due to the inherent complexity and ambiguity surrounding the interpretation of 'genomic results'. Additionally, accurately assessing a patient's level of understanding, satisfaction with, and perceived utility of such information presents an additional hurdle, further complicating efforts to ensure truly informed consent²⁶. In the reproductive context these challenges are even greater²⁷ not only because genomic sequencing is carried out with reference to a subject C (the future child), but also because of the characteristics of emotional distress and responsibility that emerge from the shift to an offspring-determinant test²⁸. Firstly, despite the inherent uncertainties in interpreting and communicating genomic results, the information derived from these results leads prospective parents to make significant and often binary decisions: whether to continue a pregnancy or not, or whether to implant a specific embryo. Secondly, as rapid technological advancements in repro-genetics, coupled with deterministic narratives around genomics²⁹, tempt prospective parents to believe they should be able to search for, understand, and operationalize the implications of each genetic variant, a new sense of parental obligation is emerging to incorporate this knowledge into reproductive decision-making³⁰. Moreover, despite the possibility of selecting complex traits remains distant, the knowledge gap between specific genotypes and complex phenotypes is gradually narrowing: genome-wide association studies and AI tools, such as machine learning, are indeed advancing knowledge by providing information about what particular genes do and also how they interact to shape polygenic traits³¹.

It is for this reason that the traditional informed consent model, currently inadequate for addressing the ethical and practical challenges posed by the growing integration of genetic biotechnologies in clinical settings, particularly in reproductive healthcare, requires serious scrutiny. By analyzing and reformulating the elements and principles of informed consent, we can not only emphasize the essential aspects needed to ensure ethical and effective communication between healthcare providers and prospective parents in this rapidly evolving field, but also assess whether a tool like GenGPT could be

MedGPT
can understand
your DNA

Call for papers:
"Intelligenza
Artificiale:
prospettive
bioetiche,
biogiuridiche e
sociali"

MedGPT
can understand
your DNA

Call for papers:
"Intelligenza
Artificiale:
prospettive
bioetiche,
biogiuridiche e
sociali"

a viable option for taking on certain tasks in genetic counseling. These include offering overviews of potential risks or outcomes associated with specific genetic variants, explaining available genetic tests and even recommending them, and providing patient-friendly explanations of complex genetic information and test results.

4. REVISING INFORMED CONSENT: MOVING BEYOND AUTONOMY

We argue that a revised and adequate model of informed consent for the reprobogenetic context requires two additional principles to the traditionally recognized elements of comprehension, disclosure and voluntariness³²: trustworthiness and value transparency.

The first one refers to the 'public and social sphere' of genomic data collecting, usage purposes, and sharing. Trustworthy systems for genomic data governance emphasize a culture of patient safety, a special attention to the instance of privacy and data allocation³³ and the making explicit of all the stakeholders involved, both direct and indirect³⁴. On the other hand, value transparency principle (VTP) refers to an approach between clinical professionals and prospective parents that diverges from the traditional principle of non-directiveness (NDP), which is foundational to the practice of genetic counseling³⁵. VTP involves not only fostering open dialogue between clinicians and prospective parents about the implications of genomic data but also acknowledging that the various stakeholders (clinicians, parents, and actors within broader social systems) may prioritize or interpret the importance of genomic information differently. By aiming to make these influences explicit and transparent, VTP ensures that prospective parents are fully informed about the reasoning behind which conditions are screened, including the implicit values underlying the selection of specific tests over others. There could also be strictly deontological reasons why such a principle is necessary to address the limitations of NDP, especially in the context of reproductive decision-making. Rooted in a commitment to respecting patient autonomy through non-interference, NDP may inadvertently undermine the professional responsibilities of genetic counseling by functioning as a defensive tool to protect clinicians from social criticism or litigation. This defensive posture may, in turn, fail

to fully support prospective parents and, in some cases, may ultimately work against the best interests of both the parents and the future child.

At its core, VTP addresses these shortcomings by recognizing that ethical decision-making, especially in sensitive contexts like the one under examination, is rarely an isolated act of personal autonomy. As underlined by Rehmann-Sutter, while genetic data should primarily be treated as private³⁶, genetic knowledge and agency inherently extend beyond the individual, encompassing a social dimension in three significant ways: backward, as it reveals information about ancestors; forward, as it anticipates characteristics of future descendants; and laterally, as it affects other family members. Furthermore, genetic data is not 'raw' or neutral; it is interpreted within a context of symbols, narratives, and discourses about genes, embodiment, and identity, making it deeply meaningful and socially constructed³⁷.

It is important to emphasize that NDP is not inherently 'wrong' or 'bad' but is insufficient as a standalone framework. As the number of disorders screened for varies widely between countries and clinics, creating a broad constellation of 'gene-worlds'³⁸ in which clinicians and prospective parents face the challenge of interpreting information that is more voluminous, complex, granular, and sometimes of unknown significance, NDP must be integrated into a broader and more comprehensive ethical model. As mentioned, while respect for autonomy as a negative obligation is a critically important value in medical ethics and has a strong tradition also in the context of reproductive rights³⁹, we argue that it does not fully capture the moral significance of a 'meaningful informed consent'. In this model, consent is not merely a legal formality or transactional event, but rather a process aimed at promoting thoughtful and responsible decision-making, particularly within the context of emerging repro-genetic decision-making pathways. Therefore, the goal of respecting autonomy must be complemented by the goal of promoting autonomy, which involves not only providing information but also ensuring that prospective parents fully understand it, along with its short- and long-term consequences. This approach may enable a form of professional selective paternalism when the exchange of value-sensitive information reaches points of tension or conflict. In such instances, physicians may, at times,

assert their position, not as an exercise of decision-making authority or manipulative dominance, but as a form of discursive relational persuasion⁴⁰ rooted in what they believe to be in the best interests of the patient or, in this case, the future child, even when, and indeed precisely because, prospective parents are capable of making decisions themselves. By reaffirming the fundamental importance of the principle of beneficence, which is often mistakenly viewed as an alternative or surrogate for autonomy, particularly in contexts of profound existential significance, such as procreation or end-of-life care, we can, as noted by Savulescu et al.⁴¹, restrict the label 'respect for autonomy' to refer to the negative duty of refraining from interference with autonomous choices; the element of trustworthiness we proposed is essential for fulfilling and protecting this principle. Conversely, we can adopt the term 'promotion of autonomy' to describe the positive duty to assist in decision-making, for which value transparency is a key principle. Although these two interpretations of the same principle have been recognized since the foundational work of Beauchamp and Childress⁴², their practical implementation, particularly in a manner that ensures their co-existence and the harmonization of the values they represent, remains largely unexplored.

It should now be clear why a digital tool like GenGPT would be inadequate in addressing the questions we have raised. As noted by Verbeek, repro-genetic biotechnologies, by granting a form of contact with the fetus that goes beyond a mere ultrasonographic 'peek into the womb'⁴³, shape new interpretive frameworks in which prospective parents' agency becomes morally more relevant. Indeed, as technology expand the scope of actionability in the procreative process, effectively 'broadening biological contingency'⁴⁴, prospective parents may increasingly face clashing preferences or desires that intersect with, or even conflict with the well-being of their future child. It is therefore crucial to emphasize that such tensions cannot be disregarded when evaluating the use of AI tools designed to assist and guide decision-making in such sensitive and complex clinical contexts. As these systems become more advanced by collecting ever-increasing amounts of data and gaining deeper insights into our lives, the risk increases that they might reach 'existential' conclusions about what would be 'rational'

for us 'to screen or not to screen'⁴⁵, which may significantly diverge from our genuine desires, shaped by our cognitive skills, emotions, and a priori beliefs⁴⁶.

Humans are often less rational, less consistently aware of their true desires, and less motivated to act in ways that promote their own or their future child's well-being than intelligent machines (or the engineers designing these tools) might assume. Consider, for example, the delicate yet unavoidable question of how to manage the broad spectrum of 'incidentalome'⁴⁷. Imagine a scenario in which prenatal screening reveals an actionable incidental finding. From the perspective of a tool like GenGPT, disregarding such information might appear irrational, as it would be deemed undesirable from a purely outcome-focused standpoint. However, prospective parents, driven by fear or other complex motivations, might prefer not to know this information. More immediate and, in some ways, radical examples arise when individuals hold deep personal or ideological beliefs that make it challenging to confront certain existential scenarios, particularly in decisions surrounding the beginning and end of life. Consider a couple undergoing in vitro fertilization who face the decision of whether to use genetic screening on embryos before implantation. While emotionally invested in the hope of having a genetically healthy child, they may also feel uncomfortable selecting embryos based on genetic traits. This unease might stem from moral dilemmas or ethical concerns about the idea of 'designer babies'. GenGPT might recommend screening embryos to maximize the probability of favorable health outcomes, presenting this as the most 'rational' choice based on medical probabilities and potential health risks. However, this recommendation may overlook the couple's deeper emotional and ethical reservations, exemplifying the tension between the AI's probability-driven conclusions and the couple's value-based considerations. Similarly, a pregnant woman might be offered prenatal testing to screen for spina bifida, a condition associated with mobility challenges and potential cognitive delays. Coming from a family that has a history of overcoming physical challenges, she holds a strong belief that individuals with disabilities deserve support, dignity, and inclusion in society. While an AI system might suggest that prenatal testing is 'rational', given the potential for

MedGPT
can understand
your DNA

Call for papers:
"Intelligenza
Artificiale:
prospettive
bioetiche,
biogiuridiche e
sociali"

MedGPT
can understand
your DNA

Call for papers:
"Intelligenza
Artificiale:
prospettive
bioetiche,
biogiuridiche e
sociali"

medical complications and long-term care, the woman's values may lead her to reject this perspective. If the AI recommends termination upon detecting the condition, its suggestion would conflict with her moral belief in the inherent worth and dignity of all lives. Her decision to proceed with the pregnancy would be guided not by medical probabilities but by her "philosophical" stance on disability.

In such cases, the necessity of embracing the principle of value transparency becomes clear. This principle involves openly discussing and critically evaluating the (legitimate) decision of prospective parents to 'opt out' of knowing such findings, as well as their decision regarding whether or not to act upon them. It requires a careful examination of their evolving narrative experiences, acknowledging that their perspectives may shift over time. Appreciating and engaging with them is crucial because human autonomy is deeply rooted in personhood — a nuanced concept that encompasses consciousness, subjectivity, and free will. Genuine respect for autonomy, and even more so its active promotion, can only occur through interactions with another autonomous agent within a framework of mutual recognition⁴⁸.

5. CONCLUSION

Artificial intelligence, particularly generative large language models like ChatGPT, holds immense promise in revolutionizing healthcare. These models have demonstrated capabilities in processing vast amounts of data and generating content that can potentially guide clinical decision-making. However, their application, especially in sensitive areas such as genetic counseling, requires careful consideration of the complex dynamics of patient-provider relationships.

While LLMs can perform many tasks much more efficiently and rapidly than humans, processing and elaborating preferences through quantitative analysis and probabilistic reasoning, they still have significant gaps in their ability to reason causally and ethically, particularly in contexts where negotiating values and goals is crucial. As a result, these tools lack the capacity to genuinely understand, respect, and balance the intricate and evolving dynamics underlying human decisions. Without the ability to engage in authentic interpersonal recognition, LLMs fail to support a dynamic and evolving

sense of autonomy, ultimately diminishing their capacity to fulfill their ethical responsibilities effectively. This limitation undermines the dual and non-mutually exclusive obligations of beneficence and autonomy. Therefore, there is a clear boundary, at least today, within which we can, and perhaps should, benefit from these tools, but beyond which we cannot venture.

NOTE

1. Lee P, Bubeck S, Petro J., "Benefits, Limits, and Risks of GPT-4 as an AI Chatbot for Medicine", *N Engl J Med.* 2023;388(13):1233-1239. doi:10.1056/NEJMs2214184; Patel, Sajan B, and Kyle Lam, "ChatGPT: the future of discharge summaries?" *The Lancet. Digital Health* vol. 5,3 (2023): e107-e108. doi:10.1016/S2589-7500(23)00021-3; Ali, Stephen R et al. "Using ChatGPT to write patient clinic letters." *The Lancet. Digital Health*, vol. 5,4 (2023): e179-e181. doi:10.1016/S2589-7500(23)00048-1.
2. Patrinos, G. P. et al. "Using ChatGPT to predict the future of personalized medicine." *The pharmacogenomics journal*, vol. 23,6 (2023): 178-184. doi:10.1038/s41397-023-00316-9.
3. Hirose, T. et al. "Diagnostic Accuracy of Differential-Diagnosis Lists Generated by Generative Pretrained Transformer 3 Chatbot for Clinical Vignettes with Common Chief Complaints: A Pilot Study." *International journal of environmental research and public health*, vol. 20,4 3378. 15 Feb. 2023, doi:10.3390/ijerph20043378.
4. Grünebaum, A. et al. "The exciting potential for ChatGPT in obstetrics and gynecology." *American journal of obstetrics and gynecology*, vol. 228,6 (2023): 696-705. doi:10.1016/j.ajog.2023.03.009; Cascella, M. et al. "Evaluating the Feasibility of ChatGPT in Healthcare: An Analysis of Multiple Clinical and Research Scenarios." *Journal of medical systems*, vol. 47,1 33. 4 Mar. 2023, doi:10.1007/s10916-023-01925-4.
5. Straw, I., and Callison-Burch, C. "Artificial Intelligence in mental health and the biases of language based models." *PloS one*, vol. 15,12 e0240376. 17 Dec. 2020, doi:10.1371/journal.pone.0240376.

6. Azamfirei, R. et al. "Large language models and the perils of their hallucinations", *Critical care* (London, England) vol. 27,1 120. 21 Mar. 2023, doi:10.1186/s13054-023-04393-x.
7. Li, H. et al. "Ethics of large language models in medicine and medical research", *The Lancet. Digital Health*, vol. 5,6 (2023): e333-e335. doi:10.1016/S2589-7500(23)00083-3.
8. Peng, C. et al. "A study of generative large language model for medical research and healthcare", *NPJ digital medicine*, vol. 6,1 210. 16 Nov. 2023, doi:10.1038/s41746-023-00958-w.
9. In the specific case of BioGPT, the Transformer language model is pre-trained on 15 million PubMed abstracts.
10. Ahimaz, P. et al. "Genetic counselors' utilization of ChatGPT in professional practice: A cross-sectional study", *American journal of medical genetics*. Part A vol. 194,4 (2024): e63493. doi:10.1002/ajmg.a.63493; Blease, C., and John T. "ChatGPT and mental healthcare: balancing benefits with risks of harms", *BMJ mental health*, vol. 26,1 (2023): e300884. doi:10.1136/bmjment-2023-300884.
11. Cheng, S. et al. "The now and future of ChatGPT and GPT in psychiatry", *Psychiatry and clinical neurosciences*, vol. 77,11 (2023): 592-596. doi:10.1111/pcn.13588.
12. Emmert-Streib, F. "Can ChatGPT understand genetics?", *European journal of human genetics: EJHG*, vol. 32,4 (2024): 371-372. doi:10.1038/s41431-023-01419-4.
13. Jinglong, G., et al. "Is ChatGPT a Good Causal Reasoner? A Comprehensive Evaluation". In *Findings of the Association for Computational Linguistics: EMNLP* (2023), Singapore. Association for Computational Linguistics.
14. Dave, T. et al. "ChatGPT in medicine: an overview of its applications, advantages, limitations, future prospects, and ethical considerations", *Frontiers in artificial intelligence*, vol. 6 1169595. 4 May. 2023, doi:10.3389/frai.2023.1169595.
15. Sezgin, E. "Redefining Virtual Assistants in Health Care: The Future With Large Language Models", *Journal of Medical Internet Research* (2024), doi: 10.2196/53225.
16. GSTs include both whole genome and whole exome sequencing, as well as chromosomal microarray. As the reference is to the reproductive context, GSTs also includes pre-implantation genetic testing, genetic testing during pregnancy (such as amniocentesis and chorionic villus sampling), and more recent innovations such as non-invasive prenatal testing, or the use of polygenic scores. Although each of these techniques raises some peculiar problems, which will be addressed during the writing of the thesis, the research question allows them to be grouped under the same heading.
17. Giannos, P., Delardas, O. "Performance of ChatGPT on UK standardized admission tests: Insights from the BMAT, TMUA, LNAT, and TSA examinations", *JMIR Medical Education*, 9 (2023), doi.org/10.2196/47737; Prasad S. S., Manohar N. "Genital and Extragenital Lichen Sclerosus et Atrophicus: A Case Series Written Using ChatGPT", *Cureus* 15(5) (2023) doi:10.7759/cureus.38987.
18. Rojas-Carabali, W. et al. "Chatbots Vs. Human Experts: Evaluating Diagnostic Performance of Chatbots in Uveitis and the Perspectives on AI Adoption in Ophthalmology", *Ocular Immunology and Inflammation*, 32(8), pp. 1591–1598 (2023), doi: 10.1080/09273948.2023.2266730.
19. Mese, I., et al., "Improving radiology workflow using ChatGPT and artificial intelligence", *Clinical Imaging*, 103 (2023), doi:10.1016/j.clinimag.2023.109993
20. Krusche, M., et al. "Diagnostic accuracy of a large language model in rheumatology: comparison of physician and ChatGPT-4", *Rheumatol International*, (2024), doi.org/10.1007/s00296-023-05464-6.
21. Krittanawong, C., Rodriguez, M., Kaplin, S., & Tang, W. H. W. "Assessing the potential of ChatGPT for patient education in the cardiology clinic", *Progress in Cardiovascular Diseases* (2023), doi.org/10.1016/j.pcad.2023.10.002.
22. Ahimaz, P., et al. "Genetic counselors' utilization of ChatGPT in professional practice: A cross-sectional study", *American Journal of Medical Genetics* (2023), doi.org/10.1002/ajmg.a.63493.
23. Caleshu, C., et al. "Contributors to and consequences of burnout among clinical genetic counselors

MedGPT
can understand
your DNA

Call for papers:
"Intelligenza
Artificiale:
prospettive
bioetiche,
biogiuridiche e
sociali"

MedGPT
can understand
your DNA

Call for papers:
"Intelligenza
Artificiale:
prospettive
bioetiche,
biogiuridiche e
sociali"

- in the United States", *Journal of Genetic Counseling*, 31, (2022), doi.org/10.1002/jgc4.1485.
24. Yang, S, et al. "Clinical Advice by Voice Assistants on Postpartum Depression: Cross-Sectional Investigation Using Apple Siri, Amazon Alexa, Google Assistant, and Microsoft Cortana", *JMIR Mhealth and Uhealth* (2021), doi:10.2196/24045.
25. Koplin, J. J et al. "Moving from 'fully' to 'appropriately' informed consent in genomics: The PROMICE framework", *Bioethics*, vol. 36,6 (2022): 655-665. doi:10.1111/bioe.13027.
26. Roberts, J. S., et al. "Patient understanding of, satisfaction with, and perceived utility of whole-genome sequencing: findings from the MedSeq Project", *Genetics in medicine: official journal of the American College of Medical Genetics* (2018), doi.org/10.1038/gim.2017.223.
27. Shkedi-Rafid, Shiri et al. "What is the meaning of a 'genomic result' in the context of pregnancy?" *European journal of human genetics: EJHG* vol. 29,2 (2021): 225-230. doi:10.1038/s41431-020-00722-8.
28. Verbeek P.P., *Moralizing Technology: Understanding and Designing the Morality of Things*, University of Chicago Press, 2013; Rueda, J. "Value change, reprogenetic technologies, and the axiological underpinnings of reproductive choice", *Bioethics*, 10.1111/bioe.13287. 8 May. 2024, doi:10.1111/bioe.13287.
29. Nelkin, D. "Molecular metaphors: the gene in popular discourse." *Nature reviews. Genetics* vol. 2,7 (2001): 555-9. doi:10.1038/35080583; Harden, K. P. "Genetic determinism, essentialism and reductionism: semantic clarity for contested science", *Nature reviews. Genetics* vol. 24,3 (2023): 197-204. doi:10.1038/s41576-022-00537-x.
30. Battisti D., *Procreative Responsibility and Assisted Reproductive Technologies*, Routledge, 2024.
31. Sigala, Rafaella E et al. "Machine Learning to Advance Human Genome-Wide Association Studies", *Genes* vol. 15,1 34. 25 Dec. 2023, doi:10.3390/genes15010034.
32. Minor J., *Informed Consent in Predictive Genetic Testing*, Springer Cham, 2016.
33. Wan, Zhiyu et al. "Sociotechnical safeguards for genomic data privacy", *Nature reviews. Genetics* vol. 23,7 (2022): 429-445. doi:10.1038/s41576-022-00455-y.
34. Steven U., "Designing Genetic Engineering Technologies for Human Values", *Etica & Politica / Ethics & Politics XXIV/2*", EUT Edizioni Università di Trieste, Trieste, 2022.
35. Schupmann, Will et al. "Re-examining the Ethics of Genetic Counselling in the Genomic Era", *Journal of bioethical inquiry* vol. 17,3 (2020): 325-335. doi:10.1007/s11673-020-09983-w.
36. Brassington, I. *The Private Life of the Genome: Genetic Information and the Right to Privacy* (2023), Routledge, London.
37. Rehmann-Sutter, C "Why Non-Directiveness is Insufficient: Ethics of Genetic Decision Making and a Model of Agency", *Medicine Studies* (1), pp. 113–129 (2009). <https://doi.org/10.1007/s12376-009-0023-7>.
38. Timmermans, S., Shostak, S. "Gene worlds", *Health: An Interdisciplinary Journal for the Social Study of Health, Illness and Medicine* (2016), 20(1), doi:10.1177/1363459315615394.
39. In the landmark 1973 ruling of *Roe v. Wade*, to provide a readily understandable example, the U.S. Supreme Court anchored the right to terminate a pregnancy in the 'right to privacy.'
40. Rubinelli, S., "Argumentation as Rational Persuasion in Doctor-Patient Communication", *Philosophy & Rhetoric* (2013), doi.org/10.5325/philrhet.46.4.0550.
41. Koplin, Julian J et al., cit.
42. Beauchamp, T., Childress, J. *Principles of Biomedical Ethics* (1979), Oxford University Press, New York.
43. Verbeek., P. P. *Moralizing technology: understanding and designing the morality of things*, Chicago University Press (2011).
44. Habermas, J. *The future of Human Nature* (2003) Polity Press, Cambridge.
45. Petrova, D., et al. "To screen or not to screen: What factors influence complex screening decisions?", *Journal of Experimental Psychology: Applied*, 22(2), (2016) <https://doi.org/10.1037/xap0000086>.
46. Rueda, J. "Value change, repro-

genetic technologies, and the axiological underpinnings of reproductive choice”, *Bioethics*, (2024), doi.org/10.1111/bioe.13287.

47. Roche, M. I., Berg, J. S. “Incidental Findings with Genomic Testing: Implications for Genetic Counseling Practice”, *Current genetic medicine reports* (2015) 3(4), pp. 166–176, doi.org/10.1007/s40142-015-0075-9.

48. Pereira, G. “Reciprocal Recognition Autonomy as a Decentred Autonomy” (2013). In: *Elements of a Critical Theory of Justice*, Palgrave Macmillan, London.

MedGPT
can understand
your DNA

Call for papers:
"Intelligenza
Artificiale:
prospettive
bioetiche,
biogiuridiche e
sociali"

Volume 9 ■ 2024

theFuture
ofScience
andEthics

63