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REVIEW

Open-Source Artificial Intelligence in medical applications

Inteligencia Artificial de Código Abierto en aplicaciones médicas

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ABSTRACT

Free and Open-Source Software (FOSS) and open-source artificial intelligence (AI) models have emerged as transformative paradigms in the educational and medical fields, promoting innovation, transparency, and decentralized collaboration. This study analyzes their impact through a systematic literature review and the examination of emblematic case studies, such as the City of Hope National Medical Center, Zauron Labs, Gene Outlook, and Cardiomentor. In the educational realm, FOSS has facilitated the creation of adaptive and personalized learning environments, reducing operational costs and fostering active participation from students and educators. Platforms like Moodle and Sakai have revolutionized online course management, while initiatives such as MIT OpenCourseWare have expanded access to high-quality educational resources, promoting a culture of transparency and collaboration.
In the medical field, open-source AI models have demonstrated their potential to improve diagnostic accuracy and personalized care. For example, the sepsis prediction model developed by City of Hope enables continuous monitoring of immunocompromised patients, while Zauron Labs' Guardian AI reduces errors in medical imaging interpretation. These applications stand out for their flexibility and ability to adapt to specific needs, making them valuable tools for clinical practice and research.

Keywords: Open Source; Artificial Intelligence; Medical Applications.

RESUMEN

El Software Libre y de Código Abierto (FOSS) y los modelos de inteligencia artificial (IA) de código abierto han emergido como paradigmas transformadores en los ámbitos educativo y médico, promoviendo la innovación, la transparencia y la colaboración descentralizada. Este estudio analiza su impacto mediante una revisión sistemática de literatura y el examen de casos de estudio emblemáticos, como el Centro Médico Nacional City of Hope, Zauron Labs, Gene Outlook y Cardiomentor. En el ámbito educativo, el FOSS ha facilitado la creación de entornos de aprendizaje adaptativos y personalizados, reduciendo costos operativos y fomentando la participación de estudiantes y docentes. Plataformas como Moodle y Sakai han revolucionado la gestión de cursos en línea, mientras que iniciativas como MIT OpenCourseWare han ampliado el acceso a recursos educativos de alta calidad, promoviendo una cultura de transparencia y colaboración.
En el campo médico, los modelos de IA de código abierto han demostrado su potencial para mejorar la precisión diagnóstica y la personalización del cuidado. Por ejemplo, el modelo predictivo de sepsis desarrollado por City of Hope permite la monitorización continua de pacientes inmunocomprometidos, mientras que Guardian AI de Zauron Labs reduce errores en la interpretación de imágenes médicas. Estas aplicaciones destacan por su flexibilidad y capacidad de adaptación a necesidades específicas, lo que las convierte en herramientas valiosas para la práctica clínica y la investigación.

Palabras clave: Código Abierto; Inteligencia Artificial; Aplicaciones Médicas.

INTRODUCTION

Free and Open Source Software (FOSS) represents a paradigm that transcends the technical, embodying a philosophy and innovative technological and cultural collaboration model. This model differs from proprietary software because it guarantees access to the source code, allowing users to execute, modify, share, and redistribute it. This openness encourages transparency, continuous innovation, and user control over the technology, underpinning a model of decentralized collaborative production, characterized by Benkler as "peer production based on the common good," where multiple actors voluntarily contribute to developing technological and cultural resources.(1)

The origin of free software can be traced back to the academic and research world from the mid-1950s, with projects such as UNIX, promoted by Bell Laboratories and the Massachusetts Institute of Technology (MIT), which allowed educational institutions access to the source code. However, between the 1970s and 1980s, restrictions on the source code generated tensions in the programming community. This prompted Richard Stallman to founded the GNU project in 1983, seeking to preserve the ethical principles of free software based on the freedom to run, study, modify, and redistribute the software. In 1991, Linus Torvalds adopted a more pragmatic approach with the launch of the Linux kernel, promoting an open and collaborative development model that Eric Raymond called a "bazaar," characterized by rapid update cycles and constant testing, as opposed to the centralized and hierarchical "cathedral" model.(2)

This reflects ideological differences within the FOSS movement. Stallman emphasized an ethical-political stance centered on individual freedoms and the social value of free software, while Torvalds prioritized the technical and practical advantages of collaborative development. The latter perspective led to the Open Source Initiative (OSI) 1998. It sought to promote open software in the business environment, highlighting its technical benefits without the ideological baggage associated with free software.

In sociocultural terms, FOSS has democratized technological knowledge, promoting digital inclusion and reducing dependence on single suppliers. However, FOSS faces practical challenges, such as the need for specialized infrastructure and integration with existing systems. However, strong global communities and growing institutional support have backed its ability to overcome these difficulties.

The FOSS movement has significantly transformed the technological and social landscape, promoting a collaborative and democratic vision of technological development. Its importance lies in defending freedom of access to knowledge and open collaboration, which are fundamental for technological innovation and more inclusive social development. This work seeks to promote the adoption and development of open-source artificial intelligence models in the medical community, strengthening the work of health professionals.

METHOD

This work was based on a methodology that combined a systematic review of the literature and the analysis of case studies to explore the impact of Free and Open Source Software (FOSS) and open source Artificial Intelligence (AI) models in the educational and medical fields. An exhaustive search was carried out in academic databases and open access repositories, using key terms related to FOSS, open source AI and their applications in education and medicine. Articles in English and Spanish were included, with no date restriction, to cover both theoretical foundations and recent developments.

The inclusion criteria focused on studies addressing FOSS applications in educational and medical settings, open source AI models, and case studies illustrating their implementation in health and education institutions. Papers focusing exclusively on proprietary software were excluded.

Emblematic case studies were selected, such as the City of Hope National Medical Center, Zauron Labs, Gene Outlook and Cardiomentor, to analyze in depth their impact on clinical practice, research and medical education.

DEVELOPMENT

FOSS has become very important in education, transforming administrative management and teaching-learning processes. In the administrative context, educational institutions face increased costs and operational efficiency challenges. FOSS emerges as a viable solution by eliminating the need for commercial licenses, allowing institutions to reallocate resources to critical infrastructure and pedagogical support. This cost reduction facilitates a more strategic investment in continuously improving educational services.

In addition, the intrinsic flexibility of open software allows institutions to adapt and customize their technological tools according to their specific needs. This capacity is beneficial in areas such as admissions management, student support with virtual assistants, and predictive assessment of academic performance. FOSS-based tools such as Moodle, Sakai, and Dokeos facilitate the creation of adaptive learning environments, which contributes significantly to educational effectiveness.[3]

From a pedagogical perspective, FOSS has shifted towards student-centered teaching models. Platforms like Moodle have revolutionized online course management, fostering dynamic interaction between students and teachers and promoting a more participatory educational experience. The collaborative approach inherent in FOSS also stimulates continuous innovation, allowing for the agile incorporation of new tools and constantly improving teaching methods and materials.

Another remarkable aspect of FOSS is its capacity to foster active communities of users and developers inside and outside institutions. This collaborative model not only facilitates the participation of students and teachers in creating and improving technological tools but also offers significant opportunities for practical learning and professional development. The global community that supports projects such as Moodle and Sakai continuously contributes innovations that improve the quality of the software, ensuring sustained support and reducing the risks of discontinuity.

Likewise, initiatives based on open educational resources (OER) and open source curricula (OSC) have expanded access to high-quality educational materials globally. Projects such as Curriki, Connexions, and MIT OpenCourseWare allow institutions and users to access, modify, and redistribute content without economic or legal restrictions, promoting greater equity in access to education.[4,5,6]

Regarding technological infrastructure, FOSS promotes the creation of more resilient and scalable systems through open and modular architectures. This facilitates the integration of technological advances and reduces dependence on commercial providers, allowing institutions to maintain their technological autonomy and adapt nimbly to changes in the digital environment.

Finally, from a sociocultural perspective, FOSS reinforces academia's community and collaborative ethos. By eliminating the barriers imposed by proprietary software, institutions can maintain control over their data and processes, fostering an environment of transparency and trust. This model strengthens the institutional capacity to share innovations and promotes a culture of continuous improvement in education. Thus, adopting FOSS in the educational sphere represents a technological decision and a strategic commitment toward a more open, inclusive, and democratic education.

Artificial Intelligence and open source

Two main approaches stand out among the multiple approaches to technological development in artificial intelligence (AI): open-source and closed platforms or those with proprietary elements. This essay thoroughly explores the definitions of the two modalities, their characteristics, their examples, and their fundamental differences.

Definitions and characteristics of open source AI platforms

Open-source Artificial Intelligence is defined as those platforms whose models, weights, and architectures are publicly accessible. Users can freely inspect, modify, and redistribute the software without special permissions, thus promoting community-driven innovation and development.[7]

Open source software must meet specific criteria established by the Open Source Initiative (OSI): distribution without restrictions, availability of the source code, the possibility of making modifications and distributing improved versions while maintaining the original conditions, absence of discrimination in its use and neutral technology, among other characteristics.[8]

Open platforms are usually characterized by their flexibility, adaptability, and capacity for customization, which allows modifications to adapt them to specific needs.

In addition, they encourage collaborative development, involving global communities in continuous innovation, which promotes rapid updates and constant improvements.[8]

FOSS introduces a model of collaborative production that favors continuous innovation and fosters technological understanding and control by users, breaking with traditional economic and political structures.[1,9]

Relevant examples of open AI

Among the various controversies brought about by the emergence of AI, since November 2022, there has been much discussion in multiple sectors of human endeavor about the social, economic, ethical, and technological implications of the impacts of this type of model and even that it should not be accessible to everyone, but even so efforts were made to develop open source models, including:

Llama and Mistral: Meta and Mistral AI platforms, respectively, with widely accessible models and architectures for modification, customization, and distribution.[9]

DeepSeek: Chinese platform offering highly competitive, affordable, and adaptable language models, even rivaling commercial models such as ChatGPT in performance.[7]

Moodle and Sakai: LMS platforms widely adopted in educational contexts, offering pedagogical customization and extensibility through plugins and supported by global communities.[8]

Differences between open and closed platforms

Technological platforms can be classified into two main categories: open and closed. Closed platforms, also known as proprietary platforms, such as GPT-4 from OpenAI or Flamingo from Google DeepMind, are characterized by keeping their source code, models, and training data in a restricted environment, which limits the capacity for customization and redistribution to specific providers.(7,10) Open platforms offer full access to their code and allow for modifications and adaptations according to the user's needs, making them a more flexible and accessible alternative.

Among the most notable differences between the two types of platforms are flexibility and customization. Open platforms allow for profound and specific adaptations, which are particularly useful in contexts where tailor-made solutions are required. In contrast, closed platforms impose significant restrictions on customization, as providers control this capability exclusively. In terms of cost and accessibility, open platforms have a considerable advantage because they do not require commercial licenses, making them cheaper and more accessible, especially for educational institutions or projects with limited budgets. In contrast, closed platforms tend to involve higher initial and recurring costs, which can represent a barrier to their adoption.

Another relevant aspect is collaborative innovation. Open platforms encourage the participation of global communities in developing and improving technologies, which accelerates technological advances through a model of continuous collaboration. In contrast, closed platforms depend on the internal development of their corporate teams, limiting innovation speed and diversity. In terms of security and technical support, closed platforms offer reliable and advanced technical support. In contrast, open platforms require users or institutions to assume this responsibility directly or to contract commercial support services.(10)

In higher education, open platforms have been widely adopted for administrative, academic, and research purposes. Notable examples include Moodle, Bodington, Claroline, and Dokeos, which offer significant flexibility in their implementation and administration. These platforms have demonstrated considerable benefits in terms of pedagogical customization, technological integration, and reduction of operating costs. On the other hand, although they offer advantages in terms of technical support and robust security, closed platforms tend to limit the capacity for independent adaptation and generate a greater dependence on the provider.(8)

The choice between open and closed platforms depends on various factors, such as the institution's specific objectives, the resources available, and strategic priorities. It is essential to consider aspects such as total costs, technical capacity, IT staff training, customization needs, security requirements, and ethical implications related to data use and management.

The impact of open-source AI has been significant and multifaceted, ranging from the economy to education and scientific research. Transparency in the architecture and accessibility of key components (code, data, and model weights) have democratized access to advanced technologies, driving accelerated and collaborative innovation. From an economic perspective, adopting open-source AI models has considerably reduced the costs associated with technological implementation and adaptation, allowing educational institutions and small companies to access advanced solutions without incurring the high costs of proprietary platforms. This has facilitated a better allocation of resources and promoted strategic investments in areas such as technological infrastructure and personnel training.

Furthermore, the spread of open models has encouraged the creation of innovative technological ecosystems where global communities collaborate on continuously improving and updating software. This community model has generated a virtuous cycle of technological development, adaptation, and distribution, contributing to technology's rapid and constant evolution. We could highlight that open platforms stand out for their transparency, adaptability, accessibility, and potential for community innovation. In contrast, closed platforms offer technical support and security advantages, although with limitations in the capacity for independent adaptation. The final decision on which type of platform to implement should be based on a careful analysis of the needs and resources of each institution or organization.(7,8)

Academic and educational impact

In education, open artificial intelligence platforms have brought about profound transformations. The accessibility of open models has enabled the personalization of learning through adaptive systems that adjust to the specific needs of each student, thus improving educational effectiveness and encouraging active participation of students in their learning process.(10)

In addition, these models have facilitated the generation of dynamic and interactive educational content, enabling teachers to design materials that adapt to the changing conditions of the academic environment and the individual level of student performance. This use has stimulated effective learning and the development of advanced digital skills essential for employability and participation in an increasingly technological society.

Impact on scientific research

Open models have also revolutionized academic research by facilitating advanced analysis of large volumes of data. Institutions can use these technologies to automate literature review processes, pattern analysis, and

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initial generation of scientific drafts, thus accelerating the pace of research and considerably expanding the scope and depth of the studies conducted.[7]

The transparency offered by open models has significantly improved the reproducibility and verifiability of scientific results, thus increasing the quality of and trust in research. This aspect is especially valuable in contexts where precision and transparency are critical, such as medical research, biotechnology, and social and economic analysis.

Social and ethical impact

On the other hand, the openness of these models implies a considerable challenge in governance and ethics. Although open access promotes transparency, it can also facilitate improper or malicious uses, which demands careful regulation and precise governance mechanisms.[11] However, compared to closed models, open platforms offer a more significant potential for transparency and accountability, fundamental characteristics for effectively addressing these risks.

In conclusion, the emergence and spread of artificial intelligence models based on FOSS have had a profound and cross-cutting positive impact in various areas, especially in education, the economy, and research. Although these models present particular challenges in terms of governance and risk control, their benefits in terms of accelerated innovation, personalization of learning, and technological democratization are indisputable. The key to maximizing these benefits is properly balancing openness and accessibility with effective governance that ensures responsible and ethical use.

Open-source Generative Artificial Intelligence Models

Open-source Artificial Intelligence (AI) Large Language Models (LLMs), such as Llama[1] or DeepSeek[2], are free to use so that institutions can employ, adapt and perfect them, democratizing access to this cutting-edge technology. This is a great advantage given that most of the LLM since their proliferation in November 2022 has been at a cost.

This approach is driving remarkable advances in medical technology, health research, and related fields, enabling academics and researchers to make fundamental progress in solving complex and difficult-to-treat problems in the interest of healthcare. Professionals such as developers and researchers can download and optimize these models in their own systems.

Another great advantage of using open-source models is that users do not have to upload data to AI services, which strengthens the protection and privacy of sensitive patient health information. The impacts of these innovations are not limited to the scientific but also to the economic, as benefits are projected in terms of population health.

City of Hope

At the City of Hope National Medical Center, three artificial intelligence models designed at its research center are currently in use: one to identify cases of sepsis, another to predict complications from surgical interventions, and a third to estimate the risk of death within 90 days in patients under palliative care.

These artificial intelligence predictive models are based on Machine Learning. This computational process involves training algorithms to detect patterns from analyzing massive amounts of data extracted from anonymous medical records. By having real-time updated patient data, such as vital signs, laboratory analyses, and imaging studies, the models calculate predictions of health status, produce risk assessments, and provide AI-generated interpretations, which greatly facilitates the work of healthcare experts.

Currently, the most significant difficulty is not developing these algorithms but establishing the means to obtain and analyze patient data in real-time, provide quick and effective responses to the medical team, and monitor and optimize their effectiveness.

From a technological perspective, the solution included integrating AI tools with Epic[3], the City of Hope's electronic medical records system, which constituted the natural working environment for hospital staff clinical procedures.

In detail the three main models developed, the three mentioned above are described:

- Predictive sepsis model: Sepsis, a complication that can lead to death associated with infections, can progress rapidly, causing severe organ damage, mainly affecting bone marrow transplant patients, who, after chemotherapy or radiation treatments, have a suppressed immune system. In these cases, there is a 5 % to 10 % risk of developing it, with a high probability of adverse outcomes. These immunocompromised patients may not show early signs such as fever, which complicates its detection. Years ago, Ryotaro Nakamura, a hematologist-oncologist at City of Hope, proposed using artificial Intelligence to predict sepsis in transplant patients, inspired not by scientific publications but by a Wall Street Journal article on stock market predictions. Although his initial idea was met with skepticism, he persevered and, together with Sanjeet Dadwal, head of Infectious Diseases, and the applied AI team led by Eftekhari, he developed a predictive model. Implemented in the hospital for almost two years, this system continuously monitors patients, assigning risk scores based on the ROC curve. Yellow or red alerts in the Epic system indicate the need for intensive monitoring and adjustments in antimicrobial treatments. Since sepsis can arise without prior symptoms, this AI model is crucial for anticipating and mitigating risks, offering a potentially life-saving tool. The integration of clinical and technological expertise has allowed the City of Hope to address a critical challenge in the care of vulnerable patients, demonstrating the value of AI in medicine today.

- Predictive Assessment of Complications in Surgery: Lily Lau Lai, M.D., a colorectal surgeon at City of Hope, emphasizes the importance of anticipating surgical complications, which range from bleeding and unhealed wounds to pneumonia, cardiac events, disability, or unwanted death. Lai argues that perfecting the identification of patients with a greater susceptibility to postoperative complications allows for optimizing their condition prior to surgery and refining the informed consent process for those involved and their families. Motivated by this need, Lai promoted the creation of an AI model to predict such complications. Although validated tools exist to assess postsurgical risks, they do not fit the characteristics of City of Hope patients. Lai indicated that the NSQIP Surgical Risk Calculator, which was developed primarily with data from non-oncology patients, is inaccurate in addressing frequent cases at her institution, where procedures involve multiple organs simultaneously. Launched in November 2021, the AI model implemented at City of Hope has proven to be a key tool. Lai highlights its ability to analyze vast volumes of data, exceeding human possibilities, and generate risk scores that support informed clinical decisions, thus strengthening surgical practice with an evidence-based approach.
- 90-day mortality prediction model: this AI model for predicting 90-day mortality, co-developed by Finly Zachariah, M.D., a palliative care specialist, is not as revolutionary as its first impression suggests, as risk estimation is common practice among clinicians to refine advanced treatments and care. Zachariah emphasizes that the objective is to reflect the patient's priorities, captured through conversations and tools such as Prepare for Your Care from the University of California in San Francisco, which can be integrated into electronic records. The California Healthcare Foundation reveals that, although 70 % prefer to die at home, only 32 % achieve this, compared to 42 % in hospitals due to poor doctor-patient communication (7 % compared to the desired 80 %). Thus, terminally ill patients are supported in decisions between length and quality of life, prioritizing their autonomy. In addition to the previous models, a predictive model of the patient experience is currently being developed that will incorporate various variables, such as demographic and socioeconomic factors and language barriers, together with data that is not always immediately accessible to the healthcare team. In parallel, AI models are being designed to understand unknown aspects of genetic mutations and to improve the accuracy of medical imaging analysis, offering possible answers to the differences in therapeutic response between patients with identical clinical and demographic characteristics.[12]

Zauron Labs

Dr. Kal Clark, vice president of informatics at the University of Texas Health San Antonio and co-founder of Zauron Labs, has used Meta's open-source AI model Llama to design a tool that helps radiologists interpret images.

In this context, Dr. Clark, backed by his more than 13 years career as a radiologist, has identified open-source artificial intelligence as a means of detecting errors in interpreting medical images, an area of particular relevance.

According to estimates, radiologists examine between 10 000 and 15 000 imaging studies a year, which is equivalent to more than 50 reviews a day in a working day. The errors associated with this activity, which are to some extent unavoidable, can lead to delays in treatment, prolong patients' discomfort, and negatively affect long-term clinical outcomes. Clark points out that, with nearly three billion imaging exams performed annually and an error rate of 4 %, the impact falls on millions of people.

To address this challenge, open-source AI models offer a way to reduce such error rates. Clark co-founded Zauron Labs about a year ago, where Guardian AI was developed. Guardian AI is a Llama-based tool that identifies potential false negatives in medical images and flags them for further evaluation, acting as technical support for radiologists.

The Guardian AI case reflects a debate in software development about the virtues of the closed or commercial approach versus the open-source approach. While some technology service providers advocate for restricted control that generates dependency and high costs, the open source model favors free accessibility, autonomy in adaptation, and data security, promoting an equitable distribution of opportunities.[13,14]

Gene Outlook

OtonoCo's project, Gene Outlook, focuses on using an open-source LLM to promote scientific discovery and facilitate the obtaining of relevant information, especially in genomics.

This platform specializes in identifying and analyzing data related to specific genes, particularly those linked to cancer patients. By integrating advanced model-based technologies like Llama, OtonoCo transforms complex genetic symbols into clear and understandable content for scientists and researchers.

Gene Outlook uses a model precisely adjusted for organisms called GeneTuned LLM as the core of its operation. OtonoCo created this model based on the Llama base model to overcome the limitations observed in other existing commercial and open-source LLM, especially about the accuracy of specific queries about specific genes and organisms. So far, GeneTuned LLM offers a high level of accuracy in four primary organisms: human, mouse, rat, and rhesus monkey, with plans to expand to other organisms such as dogs, cats, Chinese hamsters, sea urchins, zebrafish, and fruit flies.

Using open-source models is strategic for OtonoCo, allowing researchers to focus directly on scientific problems without worrying about developing entirely new algorithms. In this way, the company evaluates the suitability of the available open-source technology according to the specific nature of the research problem. Currently, Gene Outlook's scope of action is expanding beyond the study of cancer into new areas related to intestinal health and the microbiome, thus demonstrating the versatility of its approach based on the combination of artificial Intelligence and machine learning.

Given the above, the OtonoCo project represents a significant effort to enhance the field of genomic research through the intelligent and adapted use of open AI technologies, enabling the optimization of the collection and analysis of complex scientific data.[15]

Cardiomentor

This is the first Spanish public AI-based application designed for the medical field. This innovative medical tool takes advantage of advanced open-source artificial intelligence technologies, especially models developed by the scientific community, which allow for precise and detailed analysis.

Among the open-source AI models used in Cardiomentor, Stable Diffusion and Segment Anything Model (SAM) stand out. Stable diffusion is mainly used to generate and improve medical images, providing high visual quality and diagnostic accuracy. On the other hand, SAM, developed by Meta AI, allows for the precise segmentation of medical images, facilitating the identification of anatomical structures relevant to diagnosing and treating cardiac conditions.

Integrating these open models facilitates constant updates and fosters a collaborative environment, allowing cardiology and artificial Intelligence specialists to improve the tool continuously. This strategy reduces operational and technological costs and guarantees transparency, generating trust in healthcare professionals and patients.

In this way, Cardiomentor effectively illustrates how adopting open artificial intelligence models can revolutionize the medical field, providing robust and accessible tools that improve medical education and optimize clinical practice.[16]

DISCUSSION

The results of this study reveal that FOSS and open-source AI models constitute a transformative framework with profound implications in the educational, medical, and scientific research domains. The flexibility and accessibility inherent to FOSS, as evidenced in platforms such as Moodle and Sakai, facilitate the personalization of learning environments and the reduction of operating costs, aligning with Benkler's findings on decentralized collaborative production. This dynamic not only democratizes access to technological resources but also strengthens institutional autonomy in the face of the limitations imposed by proprietary software.

In the medical field, the analyzed cases of City of Hope, Zauron Labs, Gene Outlook, and Cardiomentor illustrate how open-source AI boosts innovation in this sector. The sepsis predictive model developed by the City of Hope, for example, demonstrates the ability of AI to integrate clinical data in real-time, improving decision-making in vulnerable populations such as immunocompromised patients. Likewise, Guardian AI from Zauron Labs, also based on Llama, highlights the potential of open models to reduce diagnostic errors in medical imaging, a critical area where human accuracy is limited by workload. These advances corroborate Haddad's 2024 observations on the superiority of open platforms in terms of adaptability and community collaboration over closed solutions.

However, significant challenges remain. Reliance on global communities for technical support and updates introduces discontinuity risks, especially in resource-constrained settings. In addition, the absence of standardized regulation in the use of open models raises ethical dilemmas, such as the handling of sensitive data and the potential for misuse, as Bommasani et al. warn.[11] In contrast, although they offer more significant support and security, closed platforms restrict independent innovation and perpetuate dependence on specific providers, a trade-off that institutions must carefully evaluate.

The comparison between the ideological approaches of Stallman and Torvalds reflected in the evolution of FOSS, is also relevant for open AI. While Stallman's ethical perspective emphasizes individual freedoms as an end, Torvald's pragmatism prioritizes technical efficiency, a dualism replicated in the debate between transparency and functionality in medical AI. This study suggests that by combining collaborative openness with robust management mechanisms, a hybrid approach could optimize the benefits of FOSS and open AI in healthcare, mitigating its limitations.

In sociocultural terms, FOSS and open AI promote greater digital inclusion and equity in access to knowledge, as seen in initiatives such as MIT OpenCourseWare and Gene Outlook. However, successful implementation requires overcoming barriers such as technical training and infrastructure, which demand strategic investment beyond technological adoption per se.

CONCLUSIONS

Analysis of Free and Open-Source Software (FOSS) and open-source AI models highlights their role as catalysts for technological and social innovation in the educational and medical fields. These paradigms not only offer affordable and technically flexible solutions but also embody an ethical vision of collaboration and transparency that transcends the limitations of proprietary software. The case studies confirmed that open AI, by democratizing access to advanced tools, can transform clinical practice and health research, improving diagnostic accuracy and personalization of care.

However, the benefits of FOSS and open AI are conditioned by practical and ethical challenges, including the sustainability of technical support, data security, and the need for clear regulatory frameworks. The medical community's strategic adoption of these technologies requires balancing collaborative openness with effective governance, ensuring that technological advances translate into tangible improvements in population health.

This paper proposes that integrating open-source AI models in medicine is not only viable but essential to strengthening the capacities of health professionals in a context of limited resources and growing demands. Future research should explore hybrid models that combine the best of open and closed approaches and longitudinally evaluate the impact of these technologies on equity and quality of healthcare.

BIBLIOGRAPHICAL REFERENCES

1. Benkler Y. Coase's Penguin, or, Linux and" The Nature of the Firm". Yale law journal. 2002;369–446.

2. Smith MJ. Collaborative, open, and automated data science. Massachusetts Institute of Technology; 2021.

3. Caguana DRM, González MJD, Reinoso GL. Innovación del modelo tecno-pedagógico inclusivo, a través de los entornos virtuales de aprendizaje (EVA & AVA). Polo del Conocimiento: Revista cient\'\ifico-profesional. 2021;6(3):622–35.

4. by Curriki ACE. Open and Shared Educational Resources–A Collaborative Strategy for Advancing E-Learning Communities. 2011;

5. Zhu M, Kadirova D. Self-directed learners' perceptions and experiences of learning computer science through MIT open courseware. Open Learning: The Journal of Open, Distance and e-Learning. 2022;37(4):370–85.

6. Ali Y Ben. OPEN EDUCATIONAL RESOURCES (OER) AND EQUITABLE ACCESS TO KNOWLEDGE: PROMOTING ACCESSIBILITY AND INCLUSION. En: International Conference" Actual economy: local solutions for global challenges". 2025. p. 336–69.

7. Williams R, O'Donnell J. We finally have a definition for open-source AI. MIT Technology Review [Internet]. el 22 de agosto de 2024 [citado el 5 de marzo de 2025]; Disponible en: https://www.technologyreview.com/2024/08/22/1097224/we-finally-have-a-definition-for-open-source-ai/

8. Lakhan SE, Jhunjhunwala K. Open source software in education. Educause Quarterly. 2008;31(2):32.

9. Raymond E. Linux and open-source success. IEEE Softw. 1999;16(01):85–9.

10. Haddad I. The Future Will be Open: Open as is Open Source AI [Internet]. 2024 [citado el 5 de marzo de 2025]. Disponible en: https://techstrong.tv/videos/aie-2024/the-future-will-be-open-open-as-is-open-source-ai-with-dr-ibrahim-haddad-at-aie-2024

11. Bommasani R, Klyman K, Longpre S, Kapoor S, Maslej N, Xiong B, et al. The foundation model transparency index. arXiv preprint arXiv:231012941. 2023;

https://doi.org/10.56294/mw2024486

12. Nunes M. City of Hope Web Page. 2022 [citado el 28 de febrero de 2025]. City of Hope pioneers the predictive power of artificial intelligence. Disponible en: https://www.cityofhope.org/breakthroughs/city-of-hope-pioneers-the-predictive-power-of-ai

13. Meta. As the AI race continues, open source models offer a path for all, not just the few. New York Times [Internet]. 2024 [citado el 2 de marzo de 2025]; Disponible en: https://www.nytimes.com/paidpost/2024-meta-ai/2024-meta-ai/opensource-ai-innovation.html

14. Zauron Labs. Acerca de Zauron. 2024 [citado el 2 de marzo de 2025]. Acerca de. Disponible en: https://zauronlabs.com/about/

15. OtonoCo. Fun Teaching Assistant & Patient-care | OtonoCo PTE LTD [Internet]. 2025 [citado el 5 de marzo de 2025]. Disponible en: https://www.otonocoai.com/

16. Pascual MG. Así es Cardiomentor, la primera aplicación pública basada en la IA española. EL PAÍS [Internet]. el 20 de febrero de 2025 [citado el 5 de marzo de 2025]; Disponible en: https://elpais.com/tecnologia/2025-02-21/asi-es-cardiomentor-la-primera-aplicacion-publica-basada-en-la-ia-espanola.html

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