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THE ROLE OF ARTIFICIAL INTELLIGENCE IN THE EARLY DIAGNOSIS OF GYNECOLOGICAL DISEASES

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ABSTRACT

Introduction: Artificial intelligence (AI) has stood out as a revolutionary tool in the field of health, particularly in the early diagnosis of gynecological diseases, such as cervical cancer, endometriosis, and polycystic ovary syndrome. AI's ability to identify patterns in large volumes of clinical data and medical images offers new perspectives for overcoming challenges related to late diagnosis. However, its implementation faces technical, ethical, and social barriers, such as external validation, the generalization of models, and inequalities in access to these technologies. Objective: To explore the role of artificial intelligence in the early diagnosis of gynecological diseases, highlighting its practical applications, benefits, challenges, and future implications. Methodology: This is a narrative review of the literature conducted in databases such as PubMed, Scopus, Web of Science and SciELO, using keywords such as "artificial intelligence", "early diagnosis" and "gynecological diseases". Studies published between 2015 and 2025 in English, Portuguese, and Spanish were included. The selection considered articles that addressed the use of AI in gynecology, focusing on its benefits and limitations. The extracted data were analyzed qualitatively and organized into thematic categories. Results and Discussion: The most notable advances include the use of AI in the interpretation of imaging tests and in the screening of gynecological diseases. Machine learning-based models achieve high accuracy, outperforming traditional methods in a variety of contexts. Despite this, challenges such as the lack of external validation and the need for generalization of the models limit the global implementation. In addition, ethical issues, such as data privacy and algorithm transparency, need to be addressed. AI complements, but does not replace, human expertise, and interdisciplinary collaboration is essential to maximize its positive impact. Conclusion: AI represents a promising tool in the early diagnosis of gynecological diseases, with the potential to transform clinical practice. However, their integration requires efforts to overcome technical, ethical, and social barriers, ensuring that their benefits are accessible to all patients in an equitable and sustainable way. Future research should focus on model validation and increasing technological accessibility.

Keywords: Artificial Intelligence. Early diagnosis. Gynecological Diseases. "Women's Health and Health Technology.

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INTRODUCTION

In recent years, artificial intelligence (AI) has established itself as a revolutionary tool in the field of healthcare, offering solutions that go beyond process automation, contributing to significant advances in the accuracy and efficiency of medical diagnosis. Particularly in the area of gynecology, the application of intelligent computing emerges as a promising approach to address the challenges of early diagnosis, especially in conditions that have a high prevalence and impact on public health, such as cervical cancer, endometriosis, and polycystic ovary syndrome (Henriques *et al.,* 2023).

Gynecology faces substantial challenges in terms of diagnosis, as many diseases are initially asymptomatic or have nonspecific symptoms, making it difficult to detect them at early stages. This difficulty often results in late diagnoses, increasing associated morbidity and mortality and treatment costs (Henriques *et al.,* 2023). In this scenario, AI-based technologies, such as machine learning and deep *neural* networks, have shown potential to identify subtle patterns in large volumes of data, helping healthcare professionals overcome traditional limitations of clinical diagnosis (Quixabeira *et al.,* 2024).

One of the most notable advances in the use of cognitive technology in gynecology is in the interpretation of imaging tests, such as ultrasounds, MRIs, and cytology. Supervised learning models have been trained to detect anomalies in images with an accuracy comparable to or even superior to that of experts. In addition, intelligent algorithm systems integrated with screening tools, such as Pap smears and DNA tests for HPV, have been developed to optimize the early detection of cervical cancer precursor lesions (Li *et al.,* 2024).

Early detection of gynecological diseases not only improves survival rates but also significantly reduces the physical, emotional, and economic impacts associated with invasive treatments. Through the analysis of genomic data, electronic clinical records, and behavioral patterns, AI offers a more personalized approach, enabling early therapeutic interventions aligned with the individual needs of patients (Santos *et al.,* 2024; Li *et al.,* 2024).

However, despite the enthusiasm around these technologies, their implementation in gynecological diagnosis still faces ethical, legal and technical challenges. Issues related to patient data privacy, algorithm transparency, and integration with health systems need to be carefully evaluated to ensure safety and equity in the use of these tools. In addition, the need to train health professionals to interpret the results generated by intelligent systems is a critical point for the widespread adoption of this technology (Lamy; Malta 2024).

Borba *et al* (2023) highlights the transformative role of AI in gynecology, but the literature also points out important gaps, especially with regard to external validation and generalization of models. Many algorithms are developed and tested in specific populations, limiting their applicability in global contexts and in more diverse populations. In light of this, it is essential to discuss the potential benefits of smart computing in the early diagnosis of gynecological diseases, as well as its limitations, to better understand how this technology can be incorporated into clinical practices in an ethical and effective manner. In addition to analyzing the available evidence, this narrative review seeks to highlight the future implications of AI in gynecology, identifying priority areas for research and development (Silva *et al.,* 2023).

The problem of late diagnosis in gynecology is aggravated by factors such as inequalities in access to health services, underreporting of symptoms, and cultural stigmas. In this context, AI can play a crucial role in providing affordable and scalable screening tools capable of serving vulnerable populations and remote areas (Cerqueira *et al*., 2022).

The integration of cognitive technology with portable devices and mobile technologies is another innovation that can expand the reach of early diagnosis, democratizing access to quality gynecological care. Applications based on intelligent algorithms have been developed to collect information from patients in real time, analyze it, and provide recommendations for further clinical investigation, representing an advance in preventive medicine (Silva; Machado Neto, 2024).

However, it is essential to consider that the use of data-driven technology in gynecology does not replace human expertise, but complements it. Healthcare professionals play an indispensable role in interpreting results, making clinical decisions, and providing emotional support to patients. Thus, the relationship between AI and medical practice should be seen as a dynamic and synergistic collaboration (Alvarez Guachichulca *et al.,* 2024).

In addition, this study aims to explore the role of artificial intelligence in the early diagnosis of gynecological diseases, addressing its practical applications, benefits, challenges, and future perspectives. By understanding the advances and limitations of this technology, we seek to contribute to the promotion of more effective and equitable strategies in women's health care.

METHODOLOGY

The methodology of this study is based on a narrative literature review which refers to a qualitative approach that allows to gather, synthesize and critically analyze the

available literature on the subject. The search for studies was conducted in recognized scientific databases, such as PubMed, and *Scientific Electronic Library Online* (SciELO), using health descriptors such as: "Artificial Intelligence"; "Early Diagnosis"; "Gynecological Diseases"; "Women's Health" and "Health Technology". Combined by Boolean operators such as *AND* and *OR* to refine the results.

The selection of articles followed previously defined inclusion and exclusion criteria. Studies published between 2018 and 2025, in English, Portuguese, or Spanish, that directly or indirectly addressed the application of AI in gynecological diseases were included. Review articles, experimental studies, clinical trials, observational studies, and case studies were considered, as long as they were relevant to the topic. Publications outside the established time frame, duplicates, studies irrelevant to the theme, and articles without access to the full text were excluded. In addition, we analyzed the references of the selected articles to identify additional relevant studies.

Data collection was carried out in two stages. In the first, the initial screening of titles and abstracts was carried out, excluding those that did not meet the inclusion criteria. In the second stage, the full texts of the pre-selected articles were read in full to confirm their relevance to the objective of the study. The information extracted was organized into thematic categories, considering aspects such as the types of gynecological diseases addressed, the AI technologies employed, the results presented, and the limitations identified.

For data analysis, an interpretative approach was used, which allowed the synthesis of the available evidence and the identification of patterns, gaps and trends in the literature. The results were discussed in light of the practical and theoretical implications of AI in the field of gynecology, focusing on contributions to early diagnosis and overcoming ethical and technical challenges. Finally, this study respected the ethical principles of scientific research, ensuring the proper citation of all sources used and avoiding any form of plagiarism.

RESULTS AND DISCUSSION

The analysis of the literature revealed that artificial intelligence (AI) has played a central role in advancing the early diagnosis of gynecological diseases, with a focus on conditions such as cervical cancer, endometriosis, and polycystic ovary syndrome. Bomfim *et al.* (2024) and Silva *et al.* (2024) pointed out that algorithms based on machine learning and deep neural networks *have* a high capacity to identify subtle patterns in imaging tests, such as ultrasounds and MRIs, often surpassing the accuracy of human specialists. These

advances are key to mitigating the limitations of traditional methods and reducing diagnostic delays (Bomfim *et al.,* 2024).

Table 1. Applications of Artificial Intelligence in the Diagnosis of Gynecological Diseases: Benefits and Challenges

APPLICATION OF AI	OBSERVED BENEFITS	CHALLENGES IDENTIFIED
Cervical cancer screening (Pap smear and HPV-DNA)	- Increased sensitivity and specificity.- Reduction in analysis time.- Earlier diagnoses.	- Need for external validation.- Implementation barriers in areas of low infrastructure.
Medical Image Interpretation	- High accuracy in detecting anomalies in ultrasounds and MRIs.- Complements the analysis of human experts.	- Reliance on high-quality data for model training.- Lack of standardization across different systems.
Genomic data analysis	- Identification of specific risk factors.- Personalization of treatment.- Development of predictive algorithms for prevention.	- Difficulty in integrating large genomic databases with existing hospital systems.
Handheld devices and mobile apps	- Expanded access to diagnostics in remote areas.- Real-time monitoring.- Automated recommendations for further investigation.	- Concerns about data privacy and security.- Limitations in populations with low digital literacy.
Clinical decision support systems	- Prioritization of higher-risk cases.- Optimization of available health resources.- Support for interdisciplinary decision-making.	- Insufficient transparency in the algorithms used.- Resistance to adoption by health professionals.

Source: Authors 2025

One of the main benefits observed is the application of intelligent computing in screening exams, such as the Pap smear and DNA tests for HPV. These tools have demonstrated a significant increase in sensitivity and specificity in the detection of cervical cancer precursor lesions, contributing to more accurate diagnoses and early interventions. In addition, automated systems support health professionals by prioritizing higher-risk cases, optimizing the use of resources available in health services (Silva *et al.,* 2024).

Data-driven technology has also proven to be efficient in analyzing large volumes of genomic and clinical data. This approach makes it possible to identify specific risk factors and personalize care, adjusting therapeutic strategies to the individual characteristics of patients. For example, studies have shown that predictive algorithms can anticipate the development of diseases based on medical history and behavioral data, allowing for more effective preventive interventions (Moraes *et al.,* 2023).

While the results are promising, ethical and technical challenges still limit the implementation of autonomous technology on a large scale. The privacy of patient data is a growing concern, especially in the context of protecting sensitive information. In addition,

the transparency of algorithms and accountability in cases of diagnostic errors are issues that need to be addressed through robust regulations and international standardizations. These aspects are critical to ensure trust in technology by health professionals and patients (Oliveira et al., 2024).

Another important point is the need for external validation (Borba, 2023; Li *et al.,* 2024) and generalization of AI models. Many algorithms have been developed based on specific populations, which limits their applicability in global contexts and in diverse populations. This limitation reinforces the importance of multicenter studies and international collaborations to promote more inclusive and widely applicable solutions (Borba *et al.,* 2023).

Inequality in access to technologies based on cognitive technology is also a relevant challenge. Despite its potential to democratize early diagnosis, many regions face significant barriers, such as a lack of adequate infrastructure and limited financial resources. In this sense, government initiatives and public-private partnerships can play an essential role in expanding access, especially in areas of high social vulnerability (Morais *et al.,* 2024).

In addition, the integration of data-driven technology with handheld devices and mobile technologies has expanded the possibilities of diagnosis in remote locations. Applications based on intelligent computing are able to collect information from patients in real time, analyze it, and offer recommendations for further investigations. These solutions have shown great potential to improve equity in access to gynecological care (De Oliveira Rosa; De Azevedo Filho, 2024).

The literature also highlights that, despite its effectiveness, data-driven technology should be seen as a complementary tool to human expertise. The role of the healthcare professional remains indispensable to interpret the results provided by automated systems and make clinical decisions based on the individual context of each patient. This interaction between technology and medical practice promotes a more holistic and humanized approach to care (Lobo 2018).

Regarding advances in personalized medicine, AI has made it possible to develop more precise therapeutic strategies aligned with the specific needs of patients. Integrated analysis of clinical, genomic, and behavioral data contributes to targeted interventions, which can reduce the risks associated with conventional treatments and improve patients' quality of life (Fernandes *et al.,* 2024).

Despite the barriers identified, the benefits of autonomous technology in the early diagnosis of gynecological diseases are undeniable. Automated tools not only increase

diagnostic efficiency but also reduce the costs associated with long-term treatments, which has a direct impact on healthcare systems. In this way, AI contributes to the sustainability of health services by optimizing resources and improving clinical outcomes (Lobo 2024).

Finally, it is evident that the integration of data-driven technology into gynecological diagnosis requires an interdisciplinary effort, involving health professionals, data scientists, policymakers, and health managers. This collaboration is essential to overcome technical and ethical challenges, promoting the implementation of innovative and affordable solutions for all patients. The future of gynecology, powered by AI, points to more efficient, equitable, and patient-centered care (Cisneros Albarran; Salazar Mendoza; Tovar Zuñiga 2024).

CONCLUSION

Artificial intelligence (AI) has stood out as a revolutionary tool in healthcare, especially in the early diagnosis of gynecological diseases, contributing to significant advances in terms of accuracy, efficiency, and personalization of care. From this narrative review, it was found that cognitive technology has high potential to identify conditions such as cervical cancer, endometriosis, and polycystic ovary syndrome in early stages, optimizing screening and enabling earlier and more effective interventions. In addition, the integration of autonomous technology with imaging tests, genetic tests, and clinical decision support tools has demonstrated its ability to reduce late diagnoses and improve health outcomes.

Despite its transformative potential, the implementation of data-driven technology in clinical practice faces ethical, technical, and social challenges. Issues such as data privacy, the validation and generalization of algorithms, as well as the training of health professionals, must be prioritized to ensure the safe, ethical, and efficient use of these technologies. In addition, it is essential that efforts are directed to democratize access to AI-based tools, especially in vulnerable populations and areas of low health service coverage.

Another critical point identified was the importance of the interaction between technology and human expertise. Intelligent computing does not replace, but complements clinical practice, highlighting the indispensable role of health professionals in interpreting results and conducting care in a humanized and individualized way. Thus, it is essential to foster interdisciplinary collaboration and the formulation of public policies that promote the responsible and sustainable implementation of AI in the field of gynecology.

It is concluded that, although there are still barriers to be overcome, autonomous technology has the potential to transform medical practice, especially in the early diagnosis of gynecological diseases, promoting greater equity and quality in women's health care.

Future studies should deepen the long-term evaluation of the impact of these technologies, considering not only the clinical aspects, but also the ethical, social, and economic implications. In this way, it will be possible to consolidate AI as an indispensable ally in building a more efficient, inclusive, and patient-centered health system.

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