



IMPROVING DIAGNOSIS OF CARDIOVASCULAR DISEASES BY ARTIFICIAL INTELLIGENCE IN ELECTROCARDIOGRAPHY

Aprimoramento do diagnóstico de doenças cardiovasculares
por inteligência artificial em eletrocardiografia

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ABSTRACT

Cardiovascular diseases are the leading cause of death worldwide, and the electrocardiogram (ECG) is an essential tool for diagnosis. However, errors in ECG interpretation are common. Artificial intelligence (AI) has shown promise in improving diagnostic accuracy, outperforming experts in some cases. This study aims to explore how AI can optimize the diagnosis of cardiovascular diseases by ECG and analyze the impact on clinical practice, especially in nursing. **OBJECTIVE:** To conduct a literature review on the improvement of cardiovascular disease diagnosis through the application of artificial intelligence in electrocardiography, highlighting its contributions to clinical practice and its implications for nursing practice. **METHODOLOGY:** Literature review using the main databases. **RESULTS:** The use of AI to analyze medical images, predict cardiac events, interpret electrocardiograms, personalize treatments, monitor patients remotely and optimize cardiac procedures was explored. We also discussed the ethical, regulatory and safety considerations associated with the implementation of AI in clinical practice. **CONCLUSIONS:** This review highlights the potential of AI in improving cardiology care, while highlighting the importance of addressing ethical challenges and ensuring patient safety.

Keywords: Artificial intelligence (AI), cardiovascular diseases (CVDs), electrocardiograms (ECGs), machine learning, ethics.

RESUMO

As doenças cardiovasculares são a principal causa de morte no mundo, e o eletrocardiograma (ECG) é uma ferramenta essencial para o diagnóstico. No entanto, erros na interpretação do ECG são comuns. A inteligência artificial (IA) tem se mostrado promissora na melhoria da precisão diagnóstica, superando especialistas em alguns casos. Este estudo tem como objetivo explorar como a IA pode otimizar o diagnóstico de doenças cardiovasculares por ECG e analisar o impacto na prática clínica, especialmente na enfermagem. **OBJETIVO:** Realizar uma revisão de literatura sobre a melhoria do diagnóstico de doenças cardiovasculares por meio da aplicação de inteligência artificial em eletrocardiografia, destacando suas contribuições para a prática clínica e suas implicações para a prática de enfermagem. **METODOLOGIA:** Revisão de literatura utilizando as principais bases de dados. **RESULTADOS:** O uso de IA para analisar imagens médicas, prever eventos cardíacos, interpretar eletrocardiogramas, personalizar tratamentos, monitorar pacientes remotamente e otimizar procedimentos cardíacos foi explorado. Também discutimos as considerações éticas, regulatórias e de segurança associadas à implementação da IA na prática clínica. **CONCLUSÕES:** Esta revisão destaca o potencial da IA na melhoria do atendimento cardiológico, ao mesmo tempo em que destaca a importância de abordar os desafios éticos e garantir a segurança do paciente.

Palavras-chave: Inteligência artificial (IA), doenças cardiovasculares (DCVs), eletrocardiogramas (ECGs), aprendizado de máquina (machine learning), ética.

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INTRODUCTION

Cardiovascular diseases (CVDs) are the leading cause of mortality on a global scale, accounting for more than 17 million deaths annually, according to data from the World Health Organization¹. In this context, early detection and effective management of these diseases are essential to reduce clinical complications and associated mortality. The electrocardiogram (ECG) is a diagnostic tool widely used in health services, standing out for its non-invasive nature and its ability to provide essential information about cardiac electrical activity.

Performed by applying electrodes to the skin surface, the ECG is painless, free from the risk of electric shocks or infections, and is considered a safe and easy-to-perform examination. Its clinical applicability ranges from the assessment of arrhythmias to the detection of myocardial ischemia and acute myocardial infarction (AMI), providing support for therapeutic decisions and monitoring the effectiveness of cardiovascular interventions². Despite its widespread use in clinical practice, the interpretation of the ECG by health professionals is still susceptible to errors. Studies report that between 4% and 33% of electrocardiographic interpretations contain relevant clinical errors, which raises concerns about the accuracy and reliability of the diagnosis based exclusively on human analysis³. Although echocardiography is recognized as the gold standard for the diagnosis of several CVDs, this

exam has limitations such as high cost, longer execution time and possibility of interpretative variations. In view of this, it is imperative to develop and adopt technological solutions that reconcile diagnostic accuracy with operational feasibility. In this scenario, the integration of artificial intelligence (AI) into ECG emerges as a promising strategy for screening and early diagnosis of CVDs, with the potential to reduce costs, accelerate the diagnostic process, and expand access to quality medical care⁴.

In recent years, AI has established itself as a disruptive tool in the field of medicine, especially in cardiology. The incorporation of deep learning-based algorithms into ECG has shown significant gains in terms of diagnostic accuracy and operational efficiency^{5,6}. Several studies demonstrate that such algorithms can identify cardiac anomalies with performance comparable to, and in some cases superior to, that of human experts⁵.

The use of this technology stands out for its high precision, substantially reducing the incidence of human errors and promoting more reliable diagnoses⁷. In addition to its clinical applicability, AI has contributed to the advancement of scientific research around cardiovascular health, being used as a support tool in conducting clinical studies and in generating new knowledge about the pathophysiology of CVDs.

Therefore, this work aims not only to discuss and present applications of artificial intelligence in electrocardiography, but also to analyze its impacts on diagnostic processes and scientific production in contemporary cardiology.

The increasing prevalence of cardiovascular diseases, the main cause of global morbidity and mortality, demands more effective and accurate diagnostic approaches. The integration of artificial intelligence (AI) into electrocardiography (ECG) emerges as a promising innovation, with the potential to revolutionize the early detection and management of these conditions. Recent studies demonstrate the superiority of AI, driven by deep learning algorithms, in identifying cardiac anomalies, surpassing the accuracy of human analysis in many cases. Thus, this study is justified by the need to explore the skills required of nurses, the challenges inherent in the implementation of AI and the opportunities to improve their role in the diagnosis and management of cardiovascular diseases, culminating in a better quality of life for patients.

Applications, benefits and ethical challenges of artificial intelligence in electrocardiogram interpretation

The application of artificial intelligence (AI) in electrocardiography has demonstrated great potential for analyzing large volumes of data with high speed and accuracy. This technology allows the identification of subtle changes in electrocardiographic tracings that often go unnoticed by traditional analysis methods. Scientific evidence indicates that deep learning algorithms trained to interpret electrocardiogram (ECG) patterns are capable of early detection of

conditions such as atrial fibrillation, myocardial ischemia, and heart failure⁸.

In addition to optimizing clinical response time, the use of AI in ECG contributes to the reduction of false positives and false negatives, promoting more accurate and reliable diagnoses. Figure 1, presented by Hannun et al.⁸ illustrates a deep neural network architecture capable of processing raw ECG data sampled at 200 Hz (200 samples per second), providing predictions of one of 12 possible heart rhythm classes for every 256 input samples.

According to the Regional Nursing Council of São Paulo⁹, although the incorporation of AI into clinical practice brings significant benefits, it also poses relevant ethical and operational challenges. Among these, the most important are the protection of patient data privacy, the need for transparency in algorithmic models, and the essential continuous human supervision.

Despite significant investments and recent advances, technical, ethical, and legal obstacles persist that limit the widespread adoption of these technologies in the healthcare sector. A recurring concern refers to civil liability in cases of diagnostic errors related to AI-based software. Additionally, there are risks associated with the unethical use of information, such as violating patient privacy and reproducing algorithmic biases that can exacerbate inequalities in access to health services.

Experts also point out that the trust of multidisciplinary health teams in AI technology is a critical factor for its acceptance and integration

into clinical practice. One of the main challenges is the quality of the data used to train the algorithms. Although the health system produces a large amount of data, this data is not always adequately structured or consolidated into

useful information. Incomplete or inconsistent data results in algorithms with suboptimal performance, compromising their diagnostic and therapeutic effectiveness.

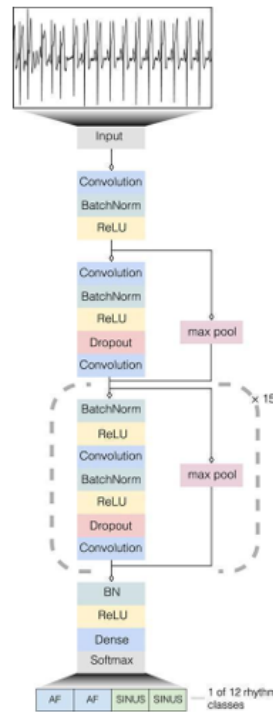


Figure 1: Deep neural network consisted of 33 convolutional layers followed by a linear output layer in a softmax ⁸.

Nursing has a critical role in healthcare cardiovascular, including performing, initial interpretation and monitoring of ECG exams. Incorporating AI into this process does not replace, but complements, the skills of nurses, enabling them to quickly identify high-risk patients and prioritize interventions. Furthermore, the use of AI-based tools requires advanced digital and technical skills from nursing professionals, reinforcing the need for ongoing training and education in digital health¹⁰. In the hospital setting, nurses are often the first to perform and review electrocardiograms, as well as monitor vital signs and changes in clinical status. Access to AI

systems can provide automated, real-time alerts to critical abnormalities, streamlining decision-making and improving clinical outcomes. For example, in intensive care units (ICUs), AI can be integrated with cardiac monitors to predict episodes of arrhythmia or impending heart failure, enabling early interventions¹¹.

Epidemiological relevance of cardiovascular diseases and the preventive role of the electrocardiogram in clinical practice

The Pan American Health Organization (PAHO/WHO) points out that cardiovascular

diseases are the leading cause of death worldwide: more people die each year from these diseases than from any other cause¹². An estimated 17.9 million people died from cardiovascular diseases in 2016, representing 31% of all deaths globally. Of these deaths, an estimated 85% are due to heart attacks and strokes. More than three-quarters of deaths from cardiovascular diseases occur in low- and middle-income countries. Of the 17 million premature deaths (people under 70 years of age) from chronic noncommunicable diseases, 82% occur in low- and middle-income countries and 37% are caused by cardiovascular diseases.

A preventive approach plays a crucial role in reducing the incidence and severity of cardiovascular diseases (CVDs), contributing to the promotion of cardiovascular health. There are several reasons that highlight the importance of preventive medicine in the context of CVDs. Prevention aims to identify and mitigate risk factors that can lead to the development of CVDs, such as hypertension, diabetes, obesity, smoking, physical inactivity, and poor diet. Addressing these risk factors is essential to reducing the likelihood of developing cardiovascular disease. Additionally, routine medical examinations play an essential role in early diagnosis. Checking blood pressure, performing blood tests to assess cholesterol and glucose levels, and performing cardiovascular assessments are all measures that can help identify health problems before they become serious. Early diagnosis allows treatment to be initiated and preventive interventions to be

implemented, preventing CVDs from reaching advanced and irreversible stages¹³.

The ECG has stood the test of time in a multitude of clinical settings. From its use as a first-line test in the evaluation of individuals with suspected acute coronary syndromes, its role in the study of arrhythmias and in the selection of individuals for interventions such as cardiac resynchronization therapy, to its combination with other methodologies (such as exercise testing or continuous monitoring), the ECG remains ubiquitous in contemporary cardiology. Furthermore, as new frameworks, such as the advent and rapid expansion of artificial intelligence, continue to transform previous paradigms, the use of the ECG as a model for new assessments further emphasizes its enduring relevance¹⁴.

Advances in artificial intelligence in automated arrhythmia detection and high-precision cardiovascular diagnosis

The 1990s and early 2000s saw the automation of a variety of medical activities, such as the interpretation of electrocardiograms (ECGs), differential white blood cell counts, and the analysis of retinal photographs¹⁵. While these systems represented significant advances, they were not error-free and continued to require human supervision to ensure accurate diagnoses.

With the advancement of artificial intelligence (AI), particularly through deep learning algorithms, there has been a significant expansion in medical applications. AI is currently being

used to identify outbreaks of infectious diseases, as demonstrated by the BlueDot system, which provided early warning of the COVID-19 outbreak in Wuhan, China¹⁶. In addition, AI is assisting in the detection of rare diseases and the interpretation of complex tests, such as CT scans and MRIs¹⁷.

Its ability to automatically learn patterns and multifaceted characteristics of raw information makes it suitable for examining ECG signals and detecting arrhythmias¹⁸. Deep learning algorithms can capture intricate temporal and spatial relationships within ECG signals, allowing the accurate classification of different types of arrhythmias. The integration of deep learning algorithms with ECG signals offers several advantages for arrhythmia detection. First, deep learning models can handle the inherent complexity and variability of ECG data, capturing the subtle patterns and features associated with different arrhythmias. These models can learn from large-scale datasets covering diverse arrhythmia cases to generalize well and improve detection accuracy. Furthermore, deep learning models can provide automated, real-time arrhythmia detection, reducing reliance on human interpretation and increasing efficiency. Once trained, these models can analyze ECG signals in real time, quickly identifying abnormal heart rhythms and alerting healthcare professionals for further evaluation and intervention. This automation streamlines the detection process, enabling faster diagnosis and timely treatment. Furthermore, the integration

of deep learning with ECG signals enables continuous monitoring, capturing transient or intermittent arrhythmias that may otherwise go unnoticed in short-term ECG recordings. Continuous monitoring enhances the ability to detect and characterize arrhythmias by providing a comprehensive assessment of the patient's cardiac rhythm over an extended period¹⁹.

Quantitative analysis of performance metrics reveals compelling evidence of AI's superior capabilities. AI systems consistently achieved higher accuracy metrics than human analysis, with sensitivity values of 0.92 (95% CI: 0.88–0.95) versus 0.85 (95% CI: 0.81–0.89). Specificity measures showed similar advantages for AI systems at 0.95 (95% CI: 0.92–0.97) compared to 0.92 (95% CI: 0.88–0.95) for human analysis. Overall performance, as measured by AUC-ROC, demonstrated superior diagnostic capabilities of AI by 0.97 (95% CI: 0.95–0.98) versus 0.93 (95% CI: 0.90–0.96) for human analysis. These consistent improvements across all metrics suggest a robust and reliable improvement in diagnostic accuracy through AI implementation²⁰.

The role of artificial intelligence in nursing practice and the prevention of critical cardiovascular events

Artificial intelligence (AI) has been progressively integrated into nursing practice, supporting a range of activities ranging from patient triage to data analysis and clinical predictions. Table 1 summarizes the main areas

Table 1 – Main applications of artificial intelligence in nursing activities		
Application of AI in Nursing	Short Description	Reference
Screening and clinical decision support	It helps in prioritizing care and making decisions based on clinical data.	Use of Artificial Intelligence in Triage in Hospital Emergency Departments: A Scoping Review ²¹
Monitoring health conditions	AI enables continuous tracking of vital signs and alerts to clinical deterioration.	Artificial Intelligence, Sensors and Vital Health Signs: A Review ²²
Medication management	Optimizes administration, reduces errors and improves treatment adherence.	Artificial Intelligence Solutions to Increase Medication Adherence in Patients With Non-communicable Diseases ²³
Care planning and coordination	Supports the organization of care activities based on predictive data.	Challenges and strategies for wide-scale artificial intelligence (AI) deployment in healthcare practices: A perspective for healthcare organizations ²⁴
Clinical documentation	Automates records, improves readability and information security.	Enhancing Clinical Documentation with AI: Reducing Errors, Improving Interoperability, and Supporting Real-Time Note-Taking ²⁵
Patient education and support	Use of chatbots and virtual assistants to guide and welcome patients.	Potential of AI-Driven Chatbots in Urology: Revolutionizing Patient Care Through Artificial Intelligence ²⁶
Data analysis and clinical predictions	It allows predicting complications, readmissions and other clinical outcomes based on big data.	Ai-driven Predictive Analytics, Healthcare Outcomes, Cost Reduction, Machine Learning, Patient Monitoring ²⁷

The integration of artificial intelligence (AI) into nursing practice has led to significant changes in the way healthcare is planned, delivered, and evaluated. As shown in Table 1, AI applications range from operational tasks, such as patient triage and monitoring, to more complex activities, such as clinical data analysis and decision-making support. These technological tools help reduce errors, increase efficiency, and personalize care, contributing to better clinical outcomes.

In addition, AI has proven to be especially useful in medication management and automated documentation, freeing nursing professionals for activities that require greater human interaction and clinical judgment. However, the literature indicates that, despite advances, the adoption of AI requires

attention to ethical aspects, adequate training, and constant supervision, ensuring that the technology complements — and does not replace — the competence and human care provided by nurses.

The use of artificial intelligence (AI) and machine learning has been shown to have a significant impact on the accuracy of diagnosis and prediction of cardiovascular events. Studies have indicated that the integration of these technologies can improve risk stratification, facilitating the early identification of conditions such as heart failure and coronary artery disease. AI has been particularly effective in analyzing cardiac imaging images and making predictions based on large volumes of data, resulting in greater diagnostic accuracy and more timely interventions²⁸.

A retrospective study used data from patients admitted to Intensive Care Units (ICUs) between 2010 and 2021 to develop and validate the DeepSEPS system, based on deep neural networks. The model demonstrated high accuracy in predicting sepsis and septic shock, outperforming traditional scoring systems such as SOFA and qSOFA. Notably, DeepSEPS was able to predict the occurrence of sepsis up to 24 hours in advance of clinical onset, presenting an area under the ROC curve (AUROC) of 0.7888 for sepsis and 0.8494 for septic shock. These findings suggest that the implementation of artificial intelligence systems, such as DeepSEPS, can significantly improve the early detection and management of patients with sepsis in intensive care settings²⁹.

Authors Lauritsen et al.³⁰ described the application of artificial intelligence (AI), specifically through deep neural networks, to predict the occurrence of sepsis in hospitalized patients. The developed model used data from electronic health records (EHRs) and was able to identify the risk of sepsis up to 24 hours in advance of the clinical onset of symptoms. The system's performance was considered promising, with a sensitivity of 85%, a specificity of 92%, and an area under the ROC curve (AUROC) of 0.76, demonstrating the potential of AI as a clinical decision support tool in intensive care settings.

Rapid technological evolution, combined with the need for constant professional development, has created a dynamic and challenging environment in which nurses must continually adapt to new equipment, procedures, and protocols in order to ensure safe, effective, and evidence-based care. In this context, by understanding the interaction between technology and care practices, it becomes possible to promote more efficient and effective nursing care that is aligned with the individual needs of the person receiving care. In this way, technology has become a strategic ally in promoting health and improving professional practices in different areas of health, especially in nursing. However, it is essential that the focus remains on humanized care, attentive to the singularities of everyone, ensuring care that is centered on the person and not just on the disease⁷.

Ethical, regulatory aspects and advanced applications of artificial intelligence in health

The integration of artificial intelligence (AI) into healthcare represents a promising advance, but it requires rigorous protection of patient data privacy and security. For its ethical and responsible use, anonymization techniques, informed consent, robust cybersecurity, transparent governance, and algorithmic explainability are essential, in compliance with legislation such as the General Data Protection Law (LGPD) in Brazil and the General Data Protection Regulation (GDPR) in the European Union³¹.

From an ethical standpoint, the transparency and interpretability of algorithms are essential to ensure the trust of professionals and patients, since the complexity of the models can make clinical understanding and validation difficult (Martins et al., 2024). The LGPD, in force since 2020, introduced rights related to the review of automated decisions, although it does not necessarily require human supervision, which can be implemented through infra-legal regulation³².

Artificial intelligence (AI) is a transformative agent in the healthcare sector, promoting the optimization of diagnostic processes and increasing the efficiency of healthcare systems. The digital training of healthcare professionals is recognized as a priority by international organizations, highlighting the fundamental role of educational institutions and professional councils in the development

of these skills³³. In the context of nursing, the implementation of AI requires a clear definition of interventions that can be delegated, as well as precise criteria for accountability in the event of technological failures, to guarantee the quality of care, economic sustainability and personalized care. In addition, it is essential to consider the associated ethical, legal and social challenges, ensuring the protection of patient data, digital rights and compliance with ethical principles in the application of these technologies.

In imaging diagnostics, AI has revolutionized areas such as ophthalmology, with reports equivalent to traditional methods³⁴, and radiodiagnosis, especially in the detection and monitoring of brain tumors, by overcoming limitations of conventional methods and allowing more precise segmentation and therapies³⁵. Furthermore, in the CT assessment of patients with COVID-19, AI significantly reduced the subjective bias of radiologists, reducing diagnostic errors by approximately tenfold, as evidenced in a randomized clinical trial³⁶.

CONCLUSION

The incorporation of Artificial Intelligence (AI) into electrocardiography has proven to be an effective strategy for improving diagnostic accuracy and optimizing the clinical management of cardiovascular diseases, the leading cause of global mortality. This review highlighted the scientific and technological

advances that enable the application of AI in the context of electrocardiograms (ECG), with emphasis on deep learning algorithms capable of detecting cardiac anomalies with performance comparable to, or even superior to, that of human experts. Despite the great potential, there are still relevant barriers to be overcome, such as ethical challenges, the need for algorithmic transparency, implementation costs, data heterogeneity, and ongoing training of healthcare teams. In this scenario, the role of the nursing team is essential, not only in the practical application of technology, but also in mediating between the patient and automated systems, ensuring focused, safe, and humanized care. Responsible implementation of AI requires collaboration between healthcare professionals, researchers, the technology industry and regulatory bodies, ensuring that clinical decisions based on algorithms respect patients' rights and promote real benefits to healthcare practice. Therefore, technology must be understood as a support tool, the success of which depends on integration with clinical knowledge and the critical and qualified performance of the professionals involved.

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REFERENCES

1. WORLD HEALTH ORGANIZATION (WHO). Cardiovascular Diseases (CVDs). [https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-\(cvds\)](https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds)) (2021).
2. Muzammil, M. A. et al. Artificial intelligence-enhanced

- electrocardiography for accurate diagnosis and management of cardiovascular diseases. *J. Electrocardiol.* 83, 30–40 (2024).
3. Salerno, S. M., Alguire, P. C. & Waxman, H. S. Training and Competency Evaluation for Interpretation of 12-Lead Electrocardiograms: Recommendations from the American College of Physicians*. *Ann. Intern. Med.* 138, 747–750 (2003).
4. Guimarães, T. B., Neves, N. S. & Souza, A. C. d'Ávila. ELECTROCARDIOGRAM DIAGNOSES PERFORMED BY ARTIFICIAL INTELLIGENCE REALIZADOS PELA INTELIGENCIA ARTIFICIAL. *Rev. Científica da UNIFENAS* 6, 44–48 (2024).
5. Attia, Z. I., Harmon, D. M., Behr, E. R. & Friedman, P. A. Application of artificial intelligence to the electrocardiogram. *Eur. Heart J.* 42, 4717–4730 (2021).
6. Corrêa Torres, R. et al. Revolucionando o Diagnóstico Cardíaco: A Eficácia da Inteligência Artificial na Interpretação de Eletrocardiogramas. *Brazilian J. Implantol. Heal. Sci.* 6, 1588–1595 (2024).
7. Alcântara, H. S. de, Almeida, D. M. de & Pinto, E. V. INTELIGENCIA ARTIFICIAL NO CUIDADO DE ENFERMAGEM: UM ESTUDO ACERCA DO FUTURO DA PROFISSÃO. *Rev. Ibero-Americana Humanidades, Ciências e Educ.* 10, 1290–1305 (2024).
8. Hannun, A. Y. et al. Cardiologist-level arrhythmia detection and classification in ambulatory electrocardiograms using a deep neural network. *Nat. Med.* 25, 65–69 (2019).
9. Coren-SP. Inteligência artificial chega à saúde. <https://portal.coren-sp.gov.br/noticias/inteligencia-artificial-chega-a-saude/> (2024).
10. Rony, M. K. K., Parvin, M. R. & Ferdousi, S. Advancing nursing practice with artificial intelligence: Enhancing preparedness for the future. *Nurs. Open* 11, (2024).
11. Rafie, N., Jentzer, J. C., Noseworthy, P. A. & Kashou, A. H. Mortality Prediction in Cardiac Intensive Care Unit Patients: A Systematic Review of Existing and Artificial Intelligence Augmented Approaches. *Front. Artif. Intell.* 5, (2022).
12. Organização Pan-Americana da Saúde. Doenças cardiovasculares - OPAS/OMS | Organização Pan-Americana da Saúde. 2022 <https://www.paho.org/pt/topicos/doencas-cardiovasculares>.
13. Brito, H. J. A. et al. O PAPEL DA MEDICINA PREVENTIVA NO COMBATE AS DOENÇAS CARDIOVASCULARES. *Rev. FOCO* 17, e4715 (2024).
14. Vilela, E. M. & Bettencourt, N. Cem Anos do Prêmio Nobel na Eletrocardiografia: Uma Tecnologia Ainda Essencial e Preparada para o Próximo Século. *Arq. Bras. Cardiol.* 121, (2024).
15. Arora, N. & Mishra, B. Origins of ECG and Evolution of Automated DSP Techniques: A Review. *IEEE Access* 9, 140853–140880 (2021).
16. Adeoye, A. et al. AI and Machine Learning for Early Detection of Infectious Diseases in the US: Opportunities and Challenges. *J. Med. Sci. Biol. Chem.* 2, 54–63 (2025).
17. Visibelli, A., Roncaglia, B., Spiga, O. & Santucci, A. The Impact of Artificial Intelligence in the Odyssey of Rare Diseases. *Biomedicines* 11, 887 (2023).
18. Merdjanovska, E. & Rashkovska, A. Comprehensive survey of computational ECG analysis: Databases, methods and applications. *Expert Syst. Appl.* 203, 117206 (2022).
19. Katal, N., Gupta, S., Verma, P. & Sharma, B. Deep-Learning-Based Arrhythmia Detection Using ECG Signals: A Comparative Study and Performance Evaluation. *Diagnostics* 13, 3605 (2023).
20. Mustafa, A. K., Ma, N. N., Mahmud, A. & Rahman, N. H. N. A COMPARATIVE ANALYSIS OF ARTIFICIAL INTELLIGENCE (AI) AND HUMAN EXPERTISE IN HEART RHYTHM DIAGNOSIS: A SYSTEMATIC REVIEW AND META-ANALYSIS. *Asian J. Med. Technol.* 4, 60–89 (2024).
21. Tyler, S. et al. Use of Artificial Intelligence in Triage in

Hospital Emergency Departments: A Scoping Review. *Cureus* (2024) doi:10.7759/cureus.59906.

22.Junaid, S. B. et al. Artificial Intelligence, Sensors and Vital Health Signs: A Review. *Appl. Sci.* 12, 11475 (2022).

23.Babel, A., Tancja, R., Mondello Malvestiti, F., Monaco, A. & Donde, S. Artificial Intelligence Solutions to Increase Medication Adherence in Patients With Non-communicable Diseases. *Front. Digit. Heal.* 3, (2021).

24.Esmailzadeh, P. Challenges and strategies for wide-scale artificial intelligence (AI) deployment in healthcare practices: A perspective for healthcare organizations. *Artif. Intell. Med.* 151, 102861 (2024).

25.Saadat, S., Khalilzad Daroukolaei, M., Qorbani, M., Hemmat, A. & Hariri, S. Enhancing Clinical Documentation with AI: Reducing Errors, Improving Interoperability, and Supporting Real-Time Note-Taking. *Infosci. Trends* 2, 1–13 (2025).

26.Talyshinskii, A., Naik, N., Hameed, B. M. Z., Juliebø-Jones, P. & Somani, B. K. Potential of AI-Driven Chatbots in Urology: Revolutionizing Patient Care Through Artificial Intelligence. *Curr. Urol. Rep.* 25, 9–18 (2024).

27.Hossain, S., Ahmed, A., Khadka, U., Sarkar, S. & Khan, N. AI-driven Predictive Analytics, Healthcare Outcomes, Cost Reduction, Machine Learning, Patient Monitoring. *Adv. Int. J. Multidiscip. Res.* 2, (2024).

28.Santos, M. M. dos et al. AVANÇOS NA PREVENÇÃO E MANEJO DAS DOENÇAS CARDIOVASCULARES: PERSPECTIVAS ATUAIS. *Periódicos Bras. Pesqui. Científica* 3, 1573–1583 (2024).

29.Kim, T. et al. Development and Validation of Deep-Learning-Based Sepsis and Septic Shock Early Prediction System (DeepSEPS) Using Real-World ICU Data. *J. Clin. Med.* 12, 7156 (2023).

30.Lauritsen, S. M. et al. Early detection of sepsis utilizing deep learning on electronic health record event sequences. (2019).

31.Wang, H. et al. Application of Medical Knowledge Graphs in Cardiology and Cardiovascular Medicine: A Brief Literature Review. *Adv. Ther.* 39, 4052–4060 (2022).

32.Dourado, D. de A. & Aith, F. M. A. A regulação da inteligência artificial na saúde no Brasil começa com a Lei Geral de Proteção de Dados Pessoais. *Rev. Saude Publica* 56, 80 (2022).

33.Carneiro, H. Inteligência Artificial ao serviço da Enfermagem. Vol. 2 No., e34356 Pages (2024).

34.Lucena, A. R. et al. Development of an application for providing corneal topography reports based on artificial intelligence. *Arq. Bras. Oftalmol.* 85, (2022).

35.Soun, J., Masudathaya, L.-A. Y., Biswas, A. & Chow, D. S. The Role of Artificial Intelligence in Neuro-oncology Imaging. in 963–976 (2023). doi:10.1007/978-1-0716-3195-9_30.

36.Bercean, B. A. et al. Evidence of a cognitive bias in the quantification of COVID-19 with CT: an artificial intelligence randomised clinical trial. *Sci. Rep.* 13, 4887 (2023).

Observação: os/(as) autores/(as) declaram não existir conflitos de interesses de qualquer natureza.