Revista de Ciencias Médicas de Pinar del Río

ISSN: 1561-3194 **RNPS:** 1877
Rev Ciencias Médicas. 2025; 29(S2): e7068

REVIEW ARTICLE

Use of artificial intelligence in neurology: analysis of algorithms and their effectiveness in medical practice

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Received: December 30, 2025
Accepted: December 31, 2025
Published: December 31, 2025

Citar como: Acurio-Padilla PE, León-Pallasco DA, Paredes-Tobar SO, Palma-Coque EJ. Uso de la inteligencia artificial en neurología: análisis de algoritmos y su efectividad en la práctica médica. Rev Ciencias Médicas [Internet]. 2025 [citado: fecha de acceso]; 29(S2): e7068. Disponible en: http://revcmpinar.sld.cu/index.php/publicaciones/article/view/7068

ABSTRACT

Introduction: neurological diseases are among the leading causes of disability and mortality, making brain health a global priority.
Objective: to examine the use of artificial intelligence algorithms in neurology and their diagnostic and therapeutic effectiveness.
Methods: a systematic review of the scientific literature was conducted across various databases. The search employed a keyword algorithm with Boolean operators to identify relevant sources. Selected studies, after applying inclusion and exclusion criteria, were critically analyzed considering timeliness, methodological quality, and thematic relevance, and integrated into the final synthesis.
Development: artificial intelligence has proven highly useful in the interpretation of neuroimaging, achieving precise identification of brain structures and early detection of neurodegenerative diseases. Deep learning models have been applied to conditions such as Alzheimer’s, Parkinson’s, and epilepsy, improving classification and prediction of clinical progression. In neuro-oncology, AI algorithms optimized biomarker evaluation and therapeutic response. However, limitations remain regarding insufficient professional training in AI, the need for ethical regulation, and variability of results depending on data quality.
Conclusions: the incorporation of artificial intelligence in neurology represents a revolutionary advance, capable of transforming the diagnosis and management of complex pathologies. Its impact lies in diagnostic precision and treatment personalization, though it requires strengthened regulatory frameworks, medical training, and clinical validation to ensure responsible and sustainable use.
Keywords: Diagnosis; Neurodegenerative Diseases; Artificial Intelligence; Neurology; Therapeutics.

ISSN: 1561-3194 RNPS: 1877
Rev Ciencias Médicas. 2025; 29(S2): e7068

INTRODUCTION

Neurological disorders are currently the leading combined cause of disability and mortality worldwide, making brain health a global priority. Simultaneously, rapid advances in artificial intelligence (AI) are revolutionizing neurological research and clinical practice. The potential of AI to enable personalized precision neurology—and to support global brain health initiatives—depends on addressing core challenges across four pillars: models, data, feasibility/equity, and regulation/innovation—through targeted, specific recommendations. (1)

Neurology and AI share a long history of collaboration and hold immense potential. Neurological disorders pose intricate challenges due to their complex manifestations and high variability. By automating image interpretation tasks, AI algorithms accurately identify brain structures and detect anomalies, accelerating diagnosis and reducing clinicians' workload. Treatment optimization benefits from AI simulations that model various scenarios and predict outcomes. Current AI systems can already replicate many sophisticated perceptual and cognitive capabilities of biological systems, such as object recognition and decision-making.(2)

Digital health—including AI- and machine learning–based technologies—has achieved significant advances across multiple areas of medical care, including neurology. While many physicians express generally positive perceptions of AI and machine learning in clinical practice, formal training in AI among neurologists remains scarce. There are few opportunities for physicians—particularly neurologists—to learn about AI-based technologies.(3)

As AI technology advances, it promises to further unravel the complexities of neurological disorders, leading to improved patient care and quality of life. The integration of AI and neurology envisions a future where innovation and compassion converge to reshape neurological care. AI has played a pivotal role in neuroimaging, offering new opportunities for dementia diagnosis and prognosis. A total of 255 studies were identified, most based on the Alzheimer's Disease Neuroimaging Initiative (ADNI) dataset; algorithmic classifiers were the most commonly used AI method (48 %), followed by discriminative models.(4,5)

AI is rapidly transforming healthcare, with applications in epilepsy growing exponentially over the past decade. Integrating AI into epilepsy management promises to revolutionize the diagnosis and treatment of this complex disorder. However, the translation of AI into routine neurological practice has not yet been successful, underscoring the need to assess current progress and address challenges and limitations—particularly in seizure detection and prediction, seizure lateralization, and seizure onset zone localization.(6)

The incorporation of advanced AI technologies into neurological care systems positions this medical field well for AI-driven innovation by 2035. Business models, ethics, regulation, and medical education must evolve in parallel. Using AI on patient data to drive healthcare innovation—with the primary goal of improving patients' lives—will facilitate widespread acceptance and adoption of the practices necessary for successful AI integration in neurology. When planning AI implementation in clinical practice, rigorous research principles must be carefully applied to avoid unjustified costs and inefficiencies while promoting meaningful health outcomes.(7)

AI-based decision support enables more reproducible and standardized evaluation of treatment response in neuro-oncology MRI, compared to manual two-dimensional tumor burden assessments using Response Assessment in Neuro-Oncology (RANO) criteria. Additionally, AI models can precisely identify electrographic biomarkers of epilepsy—such as spikes, high-frequency oscillations, and seizure patterns. Integrating AI analysis of electroencephalographic,

ISSN: 1561-3194 RNPS: 1877
Rev Ciencias Médicas. 2025; 29(S2): e7068

clinical, and behavioral data will help optimize therapy for patients with diverse neurological conditions.[8,9] Understanding the clinical evidence on AI applications in neurology is essential to guide future research and improve patient interpretation. Therefore, this study aimed to examine the use of AI algorithms in neurology and their diagnostic and therapeutic effectiveness.

METHODS

A systematic bibliographic review was designed following PRISMA 2020 guidelines to identify and synthesize evidence on AI algorithm applications in neurology. The search period spanned from June 2019 to June 2024, encompassing recent studies reflecting advances in neurological diagnosis and treatment.

Information sources included recognized databases: PubMed, Medline, Embase, Pre-Medline, Cochrane, and DARE, as well as gray literature and secondary references from relevant articles. Publications in English and Spanish were considered to ensure inclusion of both regional and international studies. The search strategy employed DeCS and MeSH terms related to "artificial intelligence," "medical imaging," "neurological diagnosis," and "neuroimaging," combined with Boolean operators (AND, OR). Temporal and thematic filters were applied.

Inclusion criteria comprised descriptive, observational, and clinical trials evaluating AI efficacy in diagnosing and managing neurological pathologies. Duplicates, articles without full-text access, irrelevant publications, and those focused on sociological or non-clinical factors were excluded.

The selection process occurred in phases: initial identification of 100 studies, removal of 20 duplicates, exclusion of 15 for irrelevance and 10 for inaccessible full text. Ultimately, 37 studies were included in the review.

Data extraction and analysis were performed independently by two reviewers, who collected key variables: author, year, methodological design, sample characteristics, intervention type, and main results. Disagreements were resolved by consensus or a third reviewer. A qualitative synthesis of findings was conducted, and when methodological homogeneity permitted, meta-analysis techniques were applied to estimate pooled effect measures.

DEVELOPMENT

When discussing AI and neurology, two key aspects must be highlighted: the reduction of human error in nearly imperceptible features and the early detection of neurodegenerative diseases that do not manifest in initial stages. As Obermeyer notes, AI has previously been used to predict psychiatric disorders and spinal atrophy, but controversy remains regarding its use for diagnosing diseases with neuroradiologist-level accuracy.[10]

Disorders of consciousness (DoC) are primarily caused by stroke (84 %), followed by traumatic brain injury, post-surgical sequelae, hypoxic-ischemic encephalopathy, and other encephalitides or encephalopathies (16 %). Kondziella et al.,[11] emphasize that AI application in neuroimaging and neurophysiological testing facilitates functional and temporal prognostication in complex scenarios, such as altered states of consciousness. Maier et al.,[12] report that brain-computer interface systems achieve 80 % efficacy due to ease of patient adaptation and adherence.

ISSN: 1561-3194 RNPS: 1877
Rev Ciencias Médicas. 2025; 29(S2): e7068

AI offers significant advances in biomedicine. Machine learning and deep learning techniques enable algorithm development for accurate patient classification and categorization through integration of complex or multi-source data. Goeks et al.,(13) note that computer-aided diagnosis accelerates analysis and extracts more information than traditional methods.

García-Gutiérrez et al.,(14) indicate AI's relevance—for example, the Mini-Mental State Examination shows high sensitivity and specificity, as do machine learning algorithms differentiating Alzheimer's disease from frontotemporal dementia with high accuracy.

AI models rely on algorithms that guide information processing, enabling machines to learn and perform specific tasks. Russell et al.,(15) analyze AI as a qualified tool for medical history analysis via natural language processing, identifying thrombosis risk factors and reducing complication risks. Raskob et al.,(16) detail AI's high impact in early thrombosis diagnosis through analysis of CT and MRI scans, demonstrating higher specificity and sensitivity than human interpretation. Clearly, AI-based medical decision-making is increasingly relevant, serving as an essential tool for implementing personalized and precision medicine.

In neurology, AI's relevance is profound due to its ability to analyze large datasets, recognize patterns, and predict outcomes—crucial for understanding complex neurological disorders and improving patient care. Castellón et al.,(17) used an artificial neural network trained to identify glioblastomas via biomarkers extracted from ^{99m}Tc-MIBI SPECT brain images using a multilayer perceptron. Analysis of 220 images yielded 97,3 % accuracy and a low 2,7 % error rate, enabling faster, more accurate glioblastoma diagnosis—the most common malignant primary brain tumor, representing 25 % of adult brain tumors.

Stroke is the third leading cause of death in Ecuador, with a 23 % mortality rate in the general population, largely due to delayed or ineffective diagnosis. Pagola,(18) describes an automated system using wearable inertial sensors to recognize movement and strength loss. Integrated with AI algorithms during acute stroke, it determined signs of impairment, paresis severity, and—combined with neuroimaging—detected ischemic zones with contrast and vascular occlusion without contrast, representing a significant technological advance.

AI has contributed substantially to medical sciences—enhancing clinical and paraclinical diagnosis, predicting complications and mortality, assessing risk factors for pre-pathogenic disease occurrence, and innovating therapeutic and surgical management. Castellazzi et al.,(19) applied machine learning algorithms to 15 dementia patients to automatically differentiate Alzheimer's from vascular dementia using MRI, achieving 84 % diagnostic accuracy.

Shinde et al.,(20) studied 45 Parkinson's disease patients, 20 with atypical parkinsonian syndromes (multiple system atrophy, progressive supranuclear palsy), and 35 healthy controls. Using deep learning (convolutional neural networks), they achieved 80 % diagnostic accuracy for Parkinson's and 87,5 % accuracy in differentiating atypical syndromes from Parkinson's disease.

Despite ongoing human cognitive evolution, intelligence must be studied as a dominant skill to uncover brain function. Research shows the human brain uses a high-dimensional network sampling mechanism to flexibly encode diverse cognitive tasks. (21) Zhou et al.,(22) highlight the need for novel neuroimaging tools to visualize these brain functions. Thus, numerous AI models require proper understanding and adaptation by healthcare personnel for effective implementation in clinical settings.

ISSN: 1561-3194 RNPS: 1877
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Defining cerebral graph resolution is crucial for improving neurological disorder diagnosis via multi-topology connectome templates. [23] Mhiri et al., [24] explain graph fusion with technology interpretation, noting its effectiveness as integrative training for healthcare staff.

Luo et al.,[25] capture multiple perspectives on brain structure, function, and connectivity—increasingly applied in diagnosing and researching brain diseases. These features may serve as clinically useful diagnostic and prognostic biomarkers. He et al.,[26] employ artificial connections between brain tracts and images to identify pathological patterns. Wang et al.,[27] justify using neurological exams supported by AI to interpret models across multiple sequences—demonstrating how a single imaging study can yield varied interpretations.

Jimenéz-Mesa et al.,[28] correlate imaging and AI system characteristics to build computer-aided diagnostic systems as clinical support tools. Using neuroimaging and machine learning (ML) to differentiate schizophrenia patients from healthy controls and detect abnormal brain regions offers clinical diagnostic reference value. Chen et al.,[29] distinguish schizophrenia from malignant neoplasms with >85 % classification accuracy using AI.

Image segmentations often differ yet show concordance between manual and model-based volumetric analyses. Gologorsky et al.,[30] reconstruct images from existing MRI data using deep volumetric segmentation models trained to identify sellar and parasellar anatomy. Neuroimaging's diagnostic benefit is widely recognized; Zhuang,[31] highlights optimal lumbar puncture segment selection—demonstrating L3–L4 as the first-choice segment for ages 10–60 via CT.

Large-scale neuroimaging datasets are crucial for neurological disorders like autism spectrum disorder, ADHD, PTSD, and Alzheimer's disease. Lanka et al.,[32] propose functional connectivity patterns for diagnostic prediction. Zhang et al.,[33] found global functional efficiency is stronger in the male brain before midlife but weakens thereafter compared to the female brain.

Key guidelines for diagnosing and treating neurological disorders center on neuroimaging—though access remains limited for many patients. Korzenierska et al.,[34] demonstrate task-related neuronal propagation events along a bidimensional axis, revealing how cognitive tasks affect propagation strength and direction across human cortical networks. Ma et al.,[35] support combining graph convolutional networks with resting-state fMRI data as a promising approach for early autism spectrum disorder diagnosis.

Finally, disorders of consciousness diagnosis must be addressed. Yang et al.,[36] describe machine learning methods for general neurological and psychiatric disorders, successfully using resting-state fMRI for patient assessment. Zheng et al.,[37] note radiotherapy's efficacy for head and neck cancer—but radiation-induced temporal lobe injury is a serious complication. Symptoms—including irreversible memory loss, cognitive decline, and even temporal lobe necrosis—can result from radiation exposure.[38]

ISSN: 1561-3194 **RNPS:** 1877
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CONCLUSIONS

AI has become a key tool in diagnosing neurological disorders, integrating into multiple processes and techniques that enhance clinical precision. Its application in neuroimaging—particularly CT and MRI—enables more accurate interpretation of brain structures and diagnostic parameters. Additionally, AI-powered robotic systems are emerging as an innovative trend to corroborate medical studies and expand diagnostic alternatives. These technological advances require proper implementation and healthcare staff training to ensure effective integration into clinical practice and improved patient care.

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