Systematic and Integrative review on Artificial intelligence in the Diagnosis of Dementia, Brain Neuroplasticity, and Healthy Aging

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Article Info

Abstract

Brain aging is a complex and heterogeneous process associated with progressive cognitive changes and an increased risk of neurodegenerative diseases, such as Alzheimer's disease. In recent decades, artificial intelligence (AI) has emerged as a strategic tool for understanding, early detection, and management of these conditions. This systematic review, conducted in accordance with the PRISMA 2020 guidelines, aimed to analyze the applications of AI in brain aging, focusing on the early detection of cognitive decline, the relationship with neuroplasticity, and the use of digital technologies in clinical and preventive contexts. The included studies demonstrate that machine learning and deep learning algorithms are widely used in the analysis of neuroimaging, EEG, and multimodal clinical data, allowing the identification of early patterns of cognitive risk. In addition, AI has been integrated into cognitive, physical, and combined interventions, as well as wearable devices, neurotechnologies, and brain-computer interfaces, contributing to personalized strategies and the promotion of healthy aging. Despite advances, challenges related to methodological standardization, clinical validation, and ethical issues remain relevant. It is concluded that artificial intelligence represents a promising resource in the care of brain aging, provided it is applied in an ethical, integrated, and evidence-based manner.

Introduction

According to Walhovd, Fjell, and Espeseth (2014) [39], brain aging is a multifactorial process characterized by progressive structural and functional changes that can result in cognitive decline and increased vulnerability to neurodegenerative diseases. This process occurs heterogeneously among individuals and is influenced by genetic, environmental, behavioral, and social factors, which reinforces the need for integrated and personalized approaches to understanding healthy aging.

In this context, the neuroscience of aging has advanced significantly by demonstrating that the brain maintains adaptive capacity throughout life, a phenomenon known as neuroplasticity (ALVES, 2024) [3]; (OLIVEIRA et al., 2025) [25]. Evidence suggests that cognitive stimuli, physical activity, multimodal interventions, and psychosocial support can modulate neural circuits, delay cognitive decline, and reduce the risk of dementia, even in advanced ages (STYLIADIS et al., 2015) [37]; (CUI et al., 2018) [8].

At the same time, the exponential growth of digital technologies and artificial intelligence-based systems has transformed the way brain aging and neurodegenerative diseases are studied, diagnosed, and monitored (LYALL et al., 2023) [19]; (GUTMAN et al., 2024) [13]. Machine learning and deep learning algorithms have shown high potential in the analysis of large volumes of clinical data, neuroimaging, electroencephalography, and cognitive profiles, contributing to the early detection of mild cognitive impairment and Alzheimer's disease (DE OLIVEIRA, 2025) [10]; (WU et al., 2024) [40].

In addition to diagnosis, artificial intelligence has been applied in the development of personalized therapeutic strategies, including cognitive rehabilitation, neuromodulation, neurofeedback, and brain-computer interfaces, expanding the possibilities for intervention in elderly populations (RUTKOWSKI et al., 2018) [31]; (CALDERONE et al., 2025) [7]. These technologies have the potential to optimize the stimulation of neuroplasticity and promote greater functional autonomy, especially in individuals at risk for dementia (KORADE et al., 2024) [16]; (XIONG, 2024) [41].

However, despite the growing volume of publications, there are still gaps in the systematization of available scientific evidence, especially regarding the integration of artificial intelligence, neuroplasticity, and brain aging in different clinical and preventiv y contexts (ONCIUL et al., 2025) [26]; (GKINTONI et al., 2025) [12]. The methodological heterogeneity of the studies, as well as the ethical and technological challenges associated with the use of artificial intelligence in health, reinforce the need for critical and rigorous syntheses of the literature.

Thus, it is essential to conduct systematic reviews that consolidate existing knowledge, identify trends, assess limitations, and guide future research and clinical applications in the field of artificial intelligence-assisted brain aging (BERNAL et al., 2024) [4]; (QANSUWA et al., 2025) [27].

In this scenario, the present systematic review seeks to contribute to the advancement of knowledge by analyzing, in a structured and evidence-based manner, the role of artificial intelligence in promoting healthy aging and preventing neurodegenerative diseases.

Objectives
General Objective
To analyze, through a systematic review of the literature, the available scientific evidence on the application of artificial intelligence (AI) in the context of brain aging, neuroplasticity, and the prevention, diagnosis, and management of dementia, with an emphasis on evidence-based approaches and innovative strategies for promoting healthy aging.

Specific Objectives
- Identify the main artificial intelligence methods and algorithms applied to the study of brain aging and neurodegenerative diseases;
- To assess the role of artificial intelligence in the early detection of cognitive decline, mild cognitive impairment, and dementias, especially Alzheimer's disease;
- Analyze the relationship between artificial intelligence, neuroplasticity, and cognitive, physical, or combined interventions in elderly populations;
- Describe emerging applications of digital technologies, wearable devices, neurotechnologies, and brain-computer interfaces in healthy aging;
- Synthesize evidence regarding the benefits, limitations, and ethical challenges of using artificial intelligence in clinical and preventive contexts related to brain aging.

Methodology
This is a systematic review of the literature conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines, with the aim of ensuring transparency, methodological rigor, and reproducibility of the study selection and analysis process.

Search Strategy
The bibliographic search was conducted in national and international electronic databases, including indexed databases relevant to the fields of neuroscience, geriatrics, artificial intelligence, and digital health. Additionally, other sources were consulted, such as reference lists of included articles and complementary literature, in order to broaden the identification of potentially eligible studies. Controlled descriptors and free terms related to *artificial intelligence*, *aging*, *neuroplasticity*, *cognitive decline*, *dementia*, and *Alzheimer's disease* were used, combined by Boolean operators.

Eligibility Criteria
Original studies, systematic reviews, narrative reviews, and observational or experimental studies addressing the application of artificial intelligence in brain aging, neuroplasticity, or dementia, published without language restrictions, were included. Duplicate articles, studies that were not directly related to the proposed topic, incomplete works, conference abstracts without full text available, and publications that did not meet the established methodological criteria were excluded.

Study Selection
The selection of studies was carried out in stages. Initially, the titles and abstracts of the identified records were

evaluated independently, and those that were clearly irrelevant were excluded. Subsequently, potentially eligible articles were submitted for full-text reading to verify compliance with the inclusion criteria. The selection process is described in detail in the PRISMA flowchart shown in Figure 1.

Data Extraction and Synthesis
From the studies included in the qualitative synthesis, information was extracted regarding the authors, year of publication, type of study, population investigated, applications of artificial intelligence, main outcomes, and conclusions. The data were organized descriptively and analyzed qualitatively, allowing the identification of patterns, convergences, and gaps in the scientific literature on the subject.

Ethical Considerations
As this is a systematic review based exclusively on secondary data available in the literature, it was not necessary to submit the study to a research ethics committee.

Results
Figure 1 presents the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart, which systematically and transparently describes the process of identification, selection, eligibility, and inclusion of the studies analyzed in this review on the application of artificial intelligence in brain aging, neuroplasticity, and dementia prevention. The use of the PRISMA flowchart allows us to detail each methodological step adopted, ensuring reproducibility, scientific rigor, and clarity regarding the criteria used for the selection of articles included in the qualitative synthesis.
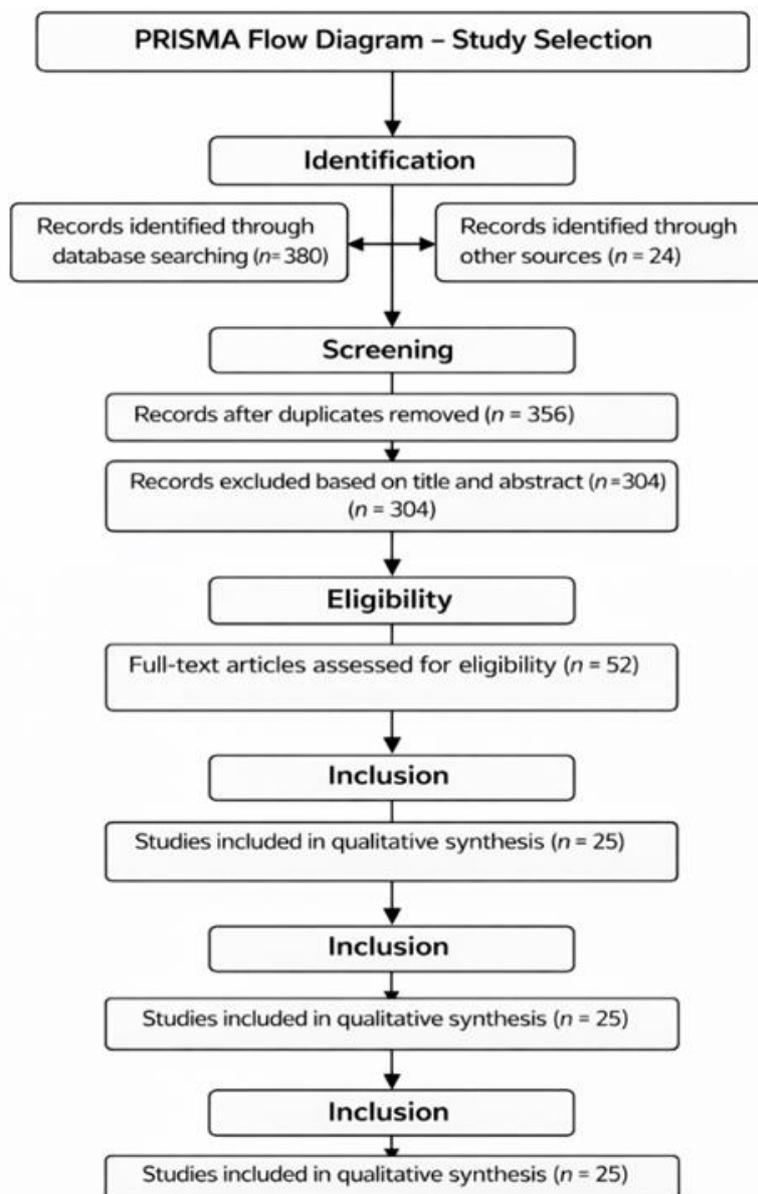

Fig 1: PRISMA flowchart of the selection of studies on artificial intelligence, neuroplasticity, and brain aging. Source: Authors

Initially, records were identified in electronic databases and other complementary sources, totaling 404 studies. After removing duplicates, 356 records remained for analysis, of which 304 were excluded after reading the titles and abstracts because they did not meet the previously established eligibility criteria. In the eligibility stage, 52 articles were evaluated in full, resulting in the final inclusion of 25 studies in the qualitative synthesis. This process highlights the careful application of methodological criteria and reinforces the consistency of the findings discussed throughout this work.

Table 1 summarizes the main artificial intelligence methods and algorithms identified in the scientific literature applied to the study of brain aging and neurodegenerative diseases. The included studies highlight the diversity of computational approaches employed, ranging from classic machine learning algorithms to advanced deep learning techniques and adaptive systems, applied to different types of neurological, cognitive, and clinical data (LYALL et al., 2023) [19]; (WU et al., 2024) [40].

Table 1: Main artificial intelligence methods and algorithms applied to the study of brain aging and neurodegenerative diseases

Author/Year	Type of Study	AI Method/Algorithm	Main Application	Disease/Context
Lyall et al., 2023 [19]	Narrative Review	Supervised Machine Learning	Predictive modeling and digital diagnosis	Dementia and brain aging
Wu et al., 2024 [40]	Systematic review	Deep learning, convolutional neural networks (CNNs)	Prediction of brain age	Healthy and pathological aging
Rutkowski et al., 2018 [31]	Methodological study	Machine learning based on information geometry	Digital EEG biomarkers	Dementia
Buscema et al., 2015 [6]	Experimental study	Adaptive AI systems (I-FAST)	EEG-based diagnosis	Alzheimer's disease
Gutman et al., 2024 [13]	Historical review	Machine learning and predictive models	Predictive medicine	Neurology and aging
De Oliveira, 2025 [10]	Narrative review	ML and DL algorithms	Early detection	Alzheimer's and Parkinson's
Calderone et al., 2025 [7]	Narrative review	AI applied to neuromodulation	Personalized therapies	Neurodegenerative diseases
Korade et al., 2024 [16]	Interdisciplinary review	AI integrated with neuroplasticity	Cognitive optimization	Mental health and aging
Xiong, 2024 [41]	Applied review	Brain-Computer Interfaces (BCI)	Communication and rehabilitation	Alzheimer's and Parkinson's
Fuentes-Mendoza et al., 2025 [11]	Narrative review	AI applied to connectome analysis	Brain plasticity	Brain tumors and aging
Onciul et al., 2025 [26]	Narrative review	Multimodal machine learning	Translational clinical research	Neuroscience
Gkintoni et al., 2025 [12]	Systematic review	EEG, AI, Virtual Reality	Cognitive rehabilitation	Mild Cognitive Impairment
Malarkhodi et al., 2024 [20]	Computational study	Supervised Machine Learning	Prediction of brain age	Aging
Natalizi et al., 2025 [24]	Observational study	ML algorithms	Brain volumetric analysis	Alzheimer
Zhang et al., 2025 [42]	Narrative review	AI applied to cognitive exercise	Cognition improvement	Elderly population
Sisubalan et al., 2025 [36]	Narrative review	AI in wearable devices	Continuous monitoring	Healthy aging

Source: Authors

It is observed that supervised machine learning and deep learning algorithms, especially convolutional neural networks, have been widely used for brain age prediction, identification of digital biomarkers, and early diagnosis of dementias, with emphasis on Alzheimer's disease (BUSCEMA et al., 2015) [6]; (RUTKOWSKI et al., 2018) [31]; (NATALIZI et al., 2025) [24]. In addition, emerging approaches such as brain-computer interfaces, AI-assisted neuromodulation, and connectome analysis broaden the scope of applications, reinforcing the role of artificial intelligence as a central tool in understanding, preventing, and managing neurodegenerative changes associated with aging (CALDERONE et al., 2025) [7]; (XIONG, 2024) [41]; (ONCIUL et al., 2025) [26].

De Oliveira (2025) [10] and Lyall et al. (2023) [19] point out that artificial intelligence has expanded the ability to identify subtle cognitive changes early on by integrating large volumes of clinical, digital, and neurophysiological biomarker data into predictive models. In this sense, Table 2 brings together the main evidence from the selected literature on the role of AI in the early detection of cognitive decline, mild cognitive impairment (MCI), and dementia, with an emphasis on strategies applied to Alzheimer's disease.

Table 2: Evidence on the role of artificial intelligence in the early detection of cognitive decline, mild cognitive impairment, and dementia (emphasis on Alzheimer's)

Author/Year	Type of study	Data/Main source	AI approach	Contribution to early detection	Target condition
Lyall *et al*., 2023 [19]	Narrative review	Digital health and clinical/multimodal data	ML applied to predictive models	Support for screening and risk stratification with digital tools	Dementia (general)
De Oliveira, 2025 [10]	Narrative review	Clinical data, imaging, and digital signals	ML and DL	Summary of applications for early detection and assisted diagnosis	Alzheimer's and Parkinson's
Wu *et al*., 2024 [40]	Systematic review	Neuroimaging and population databases	DL (incl. CNN) and ML	Prediction of "brain age" as an early marker of risk and vulnerability	Pathological aging/risk of dementia
Rutkowski *et al*., 2018 [31]	Methodological study	EEG (digital biomarker)	ML with information geometry	Development of EEG biomarkers associated with task load and dementia	Dementia
Buscema *et al*., 2015 [6]	Experimental/methodological study	Raw (unprocessed) EEG	AI system (I-FAST)	Classification/diagnostic support for Alzheimer's disease based on EEG	Alzheimer
Rossini *et al*., 2020 [29]	Biomarker study (review/neurophysiological approach)	Brain connectivity/biomarkers	Integration with analytical models (AI support)	Supports early biomarkers of neurodegenerative decline	Dementia/cognitive decline
Natalizi *et al*., 2025 [24]	Observational study	Brain volumetry + cognitive profiles	ML algorithms	Prediction/stratification of cognitive impairment (amnestic) for Alzheimer's risk	aMCI / Alzheimer's
Gkintoni *et al*., 2025 [12]	Systematic review	EEG, VR, and neuromodulation	AI applied to rehabilitation and assessment	Maps technologies for assessment/monitoring in MCI and rehabilitation	MCI
Medenica *et al*., 2024 [22]	Review/applied study	Neuropsychological assessments and rehabilitation	AI applied to neuropsychological rehabilitation	Support for assessment, monitoring, and personalization (relevant for early identification)	Brain injury/rehabilitation (cognitive risk)
Sisubalan *et al*., 2025 [36]	Narrative review	Wearables and continuous monitoring	AI in digital health	Identification of risk patterns and subtle functional/cognitive changes	Healthy aging/dementia risk
Johnstone *et al*., 2025 [15]	Consensus	Nutrition and prevention, brain health	Integration with digital models	Guides prevention and risk screening (basis for applied AI)	Dementia prevention
Onciul *et al*., 2025 [26]	Narrative review	Multimodal data in neuroscience	AI/ML in synergy with neuroscience	Translational integration for biomarkers and clinical applications	Dementias and clinical neuroscience

Source: Authors

It is observed that early detection has been supported by approaches that combine machine learning and deep learning applied to multimodal data, with neuroimaging and brain age prediction standing out as risk markers, in addition to digital biomarkers derived from EEG and brain connectivity (WU *et al*., 2024) [40]; (RUTKOWSKI *et al*., 2018) [31]; (ROSSINI *et al*., 2020) [29]. For Alzheimer's in particular, studies and reviews describe models capable of supporting screening and diagnostic classification, as well as stratifying risk in individuals with amnestic MCI based on volumetric markers and cognitive profiles, contributing to more timely and personalized interventions (BUSCEMA *et al*., 2015) [6]; (NATALIZI *et al*., 2025) [24]; (GKINTONI *et al*., 2025) [12]. Complementarily, the incorporation of monitoring by wearables and digital health tends to strengthen the longitudinal surveillance of early signs, increasing sensitivity to subtle changes throughout aging (SISUBALAN *et al*., 2025) [36].

Styliadis *et al*. (2015) [37] and Cui *et al*. (2018) [8] demonstrate that cognitive, physical, or combined interventions can positively influence cognitive and neurophysiological outcomes in older adults, supporting the hypothesis that neuroplasticity remains modifiable throughout aging. In this scenario, Table 3 systematizes the selected evidence linking artificial intelligence, neuroplasticity, and intervention strategies (cognitive training, physical exercise, combined programs, and rehabilitation), highlighting how digital technologies and computational models can support monitoring, personalization, and therapeutic optimization.

Table 3: Relationship between artificial intelligence, neuroplasticity, and cognitive, physical, or combined interventions in elderly populations

Author/Year	Type of study	Intervention (cognitive/physical/combined)	Role of AI/Technology	Indicators linked to neuroplasticity	Population/Context
Oliveira et al., 2025 [25]	Article (preventive approach)	Preventive and evidence-based interventions	AI/technologies as support for care and prevention	Neuroscientific basis for cognitive protection	Elderly people / dementia prevention
Styliadis et al., 2015 [37]	Controlled study (eLORETA)	Computerized physical + cognitive training (combined)	Computerized training tools	Changes in resting states (eLORETA) compatible with plasticity	Older adults at risk for dementia
Cui et al., 2018 [8]	Intervention study	Physical exercise (intervention associated with cognitive improvement)	Potential integration with digital monitoring	Cognitive improvement associated with intervention (functional proxy)	Alzheimer's disease
Zhang; Zhang; Luo, 2025 [42]	Review	AI-supported exercise/training	AI applied to physical/cognitive training	Improvement in cognitive function (outcomes)	Elderly population
Gkintoni et al., 2025 [12]	Systematic review	Cognitive rehabilitation and neuromodulation (includes VR/EEG)	Emerging AI in VR, EEG, neuromodulation	Neurophysiological parameters (EEG) and response to training	MCI/rehabilitation
Jirayucharoensak et al., 2019 [14]	Intervention study	Game-based neurofeedback	Digital system/feedback (basis for adaptive AI)	Modulation of cognitive performance (associated with learning/plasticity)	Healthy elderly and aMCI
Buscema et al., 2015 [6]	Experimental study	— (diagnostic focus)	AI applied to EEG (I-FAST)	Neurophysiological biomarkers useful for monitoring brain states	Alzheimer
Rutkowski et al., 2018 [31]	Methodological study	Cognitive tasks with ML load assessment	ML for digital EEG biomarkers	EEG biomarkers related to load/task	Dementia/aging
Fuentes-Mendoza et al., 2025 [11]	Narrative review	Rehabilitation/recovery associated with the connectome	AI applied to the connectome	Plasticity in networks (connectome)	Brain tumors (relevance to plasticity)
Reddy, 2025 [28]	Book chapter	Neurocognitive rehabilitation (technology)	AI for therapy personalization	Optimization of rehabilitation strategies (functional plasticity)	Rehabilitation (applicable to older adults)
Medenica; Ivanovic; Milosevic, 2024 [22]	Applied study/review	Neuropsychological rehabilitation	AI for rehabilitation and monitoring	Therapeutic adjustment and longitudinal follow-up	Brain injury/rehabilitation
Sisubalan et al., 2025 [36]	Review	Promotion of healthy aging (activity/routine)	AI + wearables	Continuous monitoring of functional patterns (adaptation proxy)	Elderly/healthy aging
Korade et al., 2024 [16]	Interdisciplinary review	Interventions for cognitive improvement and well-being	AI–neuroplasticity integration	Frames AI as a facilitator of cognitive enhancement	Aging/mental health
Qansuwa; Atalah; Salama, 2025 [27]	Review	Rehabilitation and equitable health	AI/ML applied to rehabilitation	Relationship between rehabilitation, plasticity, and algorithms	Healthcare/rehabilitation systems
Onciul et al., 2025 [26]	Narrative review	Clinical applications and research	Multimodal AI	Integration of biomarkers and interventions	Clinical neuroscience

Source: Authors

Evidence converges toward a model in which AI can act as a facilitator of adaptive interventions and longitudinal follow-up, especially when integrated with neurophysiological measures (such as EEG) and digital training platforms, allowing the capture of changes associated with learning and functional reorganization (JIRAYUCHAROENSAK et al., 2019) [14]; (RUTKOWSKI et al., 2018) [31]. Combined physical-cognitive interventions and technology-supported exercises tend to be particularly relevant for elderly populations at risk for dementia, while approaches involving virtual reality, neuromodulation, and AI-assisted rehabilitation expand the possibility of therapeutic

personalization and response assessment, bringing clinical practice closer to more accurate and data-driven strategies (GKINTONI et al., 2025) [12]; (ZHANG; ZHANG; LUO, 2025) [42]; (REDDY, 2025) [28].

Thus, the integration of AI and interventions aimed at neuroplasticity emerges as a promising axis for prevention and care in cognitive decline and dementia, although challenges remain in terms of methodological standardization and external validation for widespread application (ONCIUL et al., 2025) [26]; (QANSUWA; ATALAH; SALAMA, 2025) [27].

Graph 1 illustrates the distribution of the main emerging

applications of artificial intelligence in the context of healthy aging, as well as the benefits, limitations, and ethical challenges discussed in the studies included in this systematic review. The categories were grouped according to the type of technology employed—digital technologies, wearable devices, neurotechnologies, and brain-computer interfaces—, in addition to clinical and preventive applications and ethical discussions associated with the use of artificial intelligence in elderly populations.
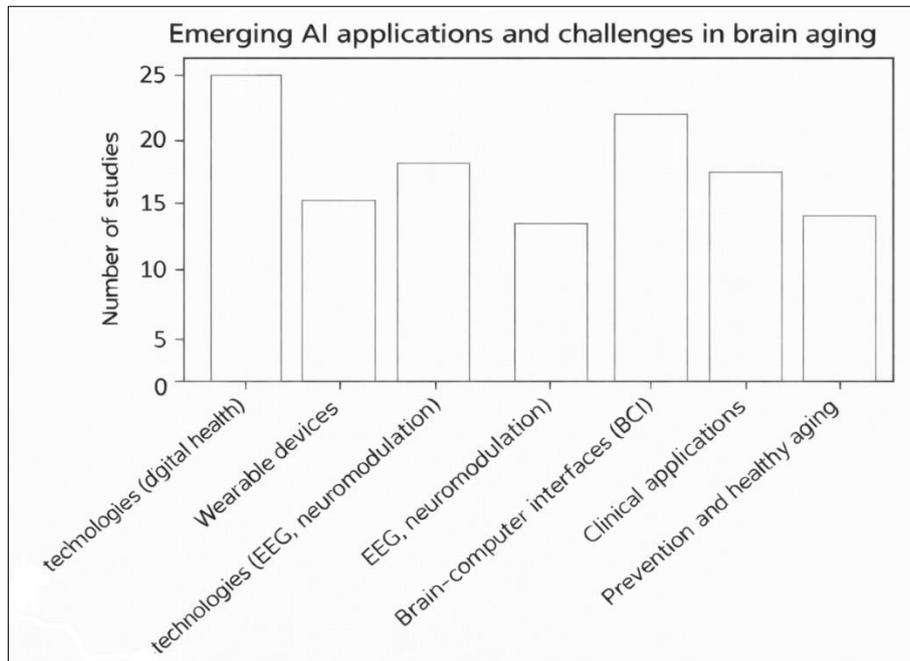
Source: Authors

Fig 1: Distribution of emerging applications of artificial intelligence in brain aging and the main ethical and clinical challenges

There is a greater concentration of studies related to digital technologies and the direct clinical applications of artificial intelligence, reflecting the growing use of digital health platforms, predictive algorithms, and clinical decision support systems in cognitive monitoring and early detection of cognitive decline (LYALL *et al*., 2023) [19]; (GUTMAN *et al*., 2024) [13].

Neurotechnologies, including EEG, neuromodulation, and neurofeedback, are also prominent, highlighting their potential for functional assessment and neuroplasticity-based interventions (RUTKOWSKI *et al*., 2018) [31]; (GKINTONI *et al*., 2025) [12]. To a lesser extent, but with growing relevance, brain-computer interfaces and wearable devices appear, associated with continuous monitoring and the personalization of preventive interventions (XIONG, 2024) [41]; (SISUBALAN *et al*., 2025) [36].

Finally, a significant number of studies address methodological limitations, ethical challenges, data privacy, and equity in access to technologies, emphasizing the need for regulation, clinical validation, and responsible approaches to the incorporation of artificial intelligence in brain aging care (ONCIUL *et al*., 2025) [26]; (QANSUWA *et al*., 2025) [27].

Discussion

Walhovd, Fjell, and Espeseth (2014) [39] emphasize that brain aging should not be understood as a linear and inevitable process of functional loss, but as a dynamic phenomenon influenced by biological, environmental, and behavioral factors throughout the course of life. In this scenario, the incorporation of artificial intelligence (AI) into neuroscience research on aging has allowed for a more refined analysis of complex patterns associated with cognitive decline and neurodegenerative diseases, expanding the capacity for prediction and early intervention (LYALL *et al*., 2023) [19]; (GUTMAN *et al*., 2024) [13].

The studies included in this review show that machine learning and deep learning algorithms have been widely used in the early detection of cognitive changes, especially through the analysis of neuroimaging, EEG, and multimodal clinical data (WU *et al*., 2024) [40]; (BUSCEMA *et al*., 2015) [6]; (NATALIZI *et al*., 2025) [24]. These approaches demonstrate significant potential for identifying individuals at risk in the early stages, such as mild cognitive impairment, favoring timely and personalized interventions (DE OLIVEIRA, 2025) [10].

In addition to diagnosis, the literature points out that AI has played an increasing role in supporting cognitive, physical, and combined interventions, with a direct impact on neuroplasticity in elderly populations (STYLIADIS *et al*., 2015) [37]; (CUI *et al*., 2018) [8]. Digital cognitive training platforms, technology-assisted physical exercise programs, and EEG-based neurofeedback systems show promise in stimulating functional reorganization and delaying cognitive decline (JIRAYUCHAROENSAK *et al*., 2019) [14]; (GKINTONI *et al*., 2025) [12].

Emerging applications of wearable devices and brain-computer interfaces further expand this scenario, allowing continuous monitoring, longitudinal assessment, and dynamic adaptation of interventions, especially in preventive and healthy aging contexts (SISUBALAN *et al*., 2025) [36]; (XIONG, 2024) [41]. However, despite technological advances, significant challenges remain related to methodological standardization, external validation of models, and effective integration of these tools into clinical practice (ONCIUL *et al*., 2025) [26].

Additionally, ethical aspects, such as data privacy, algorithmic bias, and equity in access to technologies, are widely discussed in the literature and represent important obstacles to the safe and responsible implementation of AI in health (QANSUWA; ATALAH; SALAMA, 2025) [27]; (BERNAL *et al*., 2024) [4]. Thus, there is a clear need for interdisciplinary approaches that reconcile technological innovation, scientific rigor, and ethical responsibility.

Conclusions

This systematic review shows that artificial intelligence has established itself as a central tool in research and care related to brain aging and neurodegenerative diseases. The findings demonstrate that machine learning and deep learning algorithms contribute significantly to the early detection of cognitive decline, especially in Alzheimer's disease, by integrating clinical, neurophysiological, and digital data.

In addition, AI plays an important role in optimizing cognitive, physical, and combined interventions, favoring personalized strategies that enhance neuroplasticity in elderly populations. Digital technologies, wearable devices, neurotechnologies, and brain-computer interfaces expand the possibilities for continuous monitoring and prevention, bringing clinical practice closer to more accurate, data-driven models.

However, despite the promising potential, methodological, clinical, and ethical challenges persist that limit the widespread application of these technologies. Thus, future research should prioritize robust clinical validation, standardization of methods, and incorporation of ethical principles to ensure that artificial intelligence is used safely, equitably, and effectively in the context of brain aging.

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