

Contemporary Methods of Early Diagnosis of Neurological Diseases: International Research Experience

[Nurlan Koszhanov](#)

Doctor-neurologist of the highest category, Via Medical Multidisciplinary Medical Center,
Almaty, Kazakhstan. E-mail: nurlan.nauka@gmail.com

Abstract

The significant increase in scientific papers reflects growing interest in the early detection of neurological diseases, driven by advances in neuroimaging, artificial intelligence and biomarker research.

The overarching goal is to identify key trends and innovative methods that improve diagnostic accuracy and timeliness, thereby optimizing patient outcomes in the early stages of neurological diseases.

This study analyzes 6132 publications in the Scopus database (1946-2024) related to the keywords "diagnosis" and "neurology". The rapid growth in scientific output underscores an emerging focus on early detection of neurological disorders, facilitated by advancements in neuroimaging, artificial intelligence, and biomarker research.

Research-oriented articles were selected based on the keywords "Diagnostics" and "Neurology," and as a result, the 6132 selected scientific publications underwent statistical analysis using the SPSS program. The descriptive statistics method was used to study the dynamics of publications by year, leading countries, leading organizations, and major research areas.

Analysis reveals a substantial rise in publications over the last decade, particularly in the fields of medicine, engineering, and computer science. The United States leads in overall output, followed by the United Kingdom and Germany. Collaborative, multidisciplinary research has contributed to emerging technologies ranging from advanced imaging modalities to AI-driven diagnostic tools that are increasingly crucial in detecting neurodegenerative and cognitive disorders at preclinical stages.

A systematic review of publication activity highlights the growing global emphasis on early neurological diagnosis. Despite cost and accessibility challenges, integrating neuroimaging, AI systems, and biomarker technologies holds great promise for refining diagnostic precision, fostering international collaboration, and expanding the frontiers of neurological research.

Keywords: neurology, early diagnosis, neuroimaging, biomarkers, Scopus, statistical analysis.

Corresponding author: Nurlan Koszhanov, Doctor-neurologist of the highest category, Via Medical Multidisciplinary Medical Center,
Almaty, Kazakhstan
Postal code: 050060
Address: Kazakhstan, Almaty, Rozybakieva str. 218a
Phone: +7 7055965060
E-mail: nurlan.nauka@gmail.com

2025; 125 (1): 10-19
Received: 08-11-2024
Accepted: 27-12-2024



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Introduction

Contemporary methods of early diagnosis of neurological diseases acquire particular importance in light of the increasing prevalence of these pathologies and their serious impact on patients' quality of life. Early diagnosis allows diseases to be identified in a timely manner; minimizes their consequences, and substantially reduces the economic burden on healthcare. Rapid technological development in international practice, including neuroimaging, biomarkers, and artificial intelligence, is opening new horizons for detecting neurological disorders in their early stages. However, despite these advances, the need to adapt such methods in different countries, consider regional specificities, and develop universal approaches remains relevant, highlighting the significance of the present study.

Early diagnosis of neurological diseases plays a decisive role in timely intervention and the management of conditions such as Alzheimer's disease (AD) and autism spectrum disorders (ASD), since there are still no definitive treatments for many of them [1,2]. Against the backdrop of rapid progress in artificial intelligence (AI), neuroimaging, and genetic sequencing, particular attention is being paid to quantitative electroencephalography (QEEG), which makes it possible to evaluate cognitive impairments in a wide range of patients and, specifically, to detect concentration disorders among professional pilots [3]. In addition, AI technologies can process large volumes of data and reveal patterns that can elude clinicians, thus significantly increasing diagnostic accuracy [1,2]. The use of genetic methods remains an important area, among which clinical (CES) and whole-exome sequencing (WES) are facilitating the identification of new gene variants in idiopathic neurodevelopmental disorders [4]. In the context of imaging methods, the use of functional magnetic resonance imaging (fMRI) in combination with the graph canonical correlation analysis (GATE) algorithm is promising, as it improves the detection accuracy of pathological patterns of brain activity [5]. At the same time, there is an ongoing issue of misinterpreting symptoms when functional neurological disorders (FND) are often mistaken for organic pathologies [6]. A multidisciplinary approach involving neurologists, psychiatrists, and other specialists makes it possible to expand diagnostic capabilities and combat patient stigmatization [7]. Special attention should be given to predicting neurological disorders in pediatric

practice, where machine learning techniques demonstrate high effectiveness in detecting early signs and, consequently, increase the likelihood of timely correction [8].

Based on an analysis of publication activity from 1946 to 2024 using the keywords "diagnosis" and "neurology" in the Scopus database, 6132 scientific works were identified, underscoring the sustained interest of researchers in this topic. The United States has the largest number of publications (1781), followed by the United Kingdom (633), Germany (487), China (387), and India (346), reflecting the global involvement of countries with varying levels of scientific and technological development. Italy (272), France (255), and Canada (244) also make significant contributions, continuing to shape a multinational research landscape. Notably, even countries with a relatively small number of publications, such as the Russian Federation (113), Kazakhstan (5), or Malaysia (37), further develop this field and confirm its international scope. Thus, a broad range of authors worldwide underscores the multifaceted nature and importance of research related to diagnosis in neurology, as well as the need for interdisciplinary and multicultural collaboration among specialists.

Our study, "Contemporary Methods of Early Diagnosis of Neurological Diseases: International Research Experience," aims at a comprehensive analysis of scientific publications selected by the keywords "diagnosis" and "neurology" and indexed in the Scopus database for the period from 1946 to 2024. The primary goal is to identify and consolidate leading trends, innovative approaches, and methodological solutions applied in the early diagnosis of neurological diseases. In pursuit of this goal, we plan to conduct a quantitative analysis of publication activity dynamics, determine the geographical distribution of research, and identify the most notable scientific teams and journals shaping the research agenda in this field. A detailed review of key technologies will also be carried out, including neuroimaging, artificial intelligence, and biomarkers that are actively used in international early diagnostic practices. Such an approach will allow us to systematize contemporary methods and outline future avenues for research that contribute to more effective detection and treatment of neurological diseases on a global scale.

Materials and Methodology

This study is based on the evaluation of 6132 publications indexed between 1946 and 2024, using the keywords "diagnosis" and "neurology." Such a time range was selected to cover the broadest possible spectrum of works related to identifying and studying neurological conditions. The majority of the sources retrieved are articles (4040), indicating a prevalence of original research, empirical observations, and detailed experiments. A substantial number of conference materials (897) reflects the innovative nature of the field, as findings are often presented at specialized scientific forums. Reviews (685) occupy a separate position, providing a systematic overview of key concepts, theoretical approaches, and clinical practice trends. Less common but nonetheless crucial for understanding scientific progress over time are editorial articles (148), notes (103), letters (88), book chapters (68), and short surveys (44).

Among other document types, corrections and retractions (Erratum and Retracted) also appear, along with rare instances like Data Paper (1), reflecting the diversity of the scientific landscape. The study's comprehensiveness

is further strengthened by examining leading academic editions with a well-established tradition of publishing on neurological topics. Among the most frequently encountered are BMJ Case Reports (434), Neurology (108), as well as the Annual International Conference Of The IEEE Engineering In Medicine And Biology Proceedings (95). Their presence in various journals and conference series, including Lecture Notes In Computer Science and IEEE Transactions On Biomedical Engineering, underscores the multidisciplinary nature of the field. Papers in Journal Of Neurology (44), Archives Of Neurology (42), European Journal Of Radiology (39), and several others provide a thorough view of methodological diversity, geographical coverage, and a focus on particular diagnostic and clinical observation aspects.

The inclusion of research from a wide range of countries illustrates the high significance of these issues, further supported by the extensive use of technologies from traditional neuroimaging to the most advanced computer-based methods. Such a selection of sources enables taking into account both the applied and the fundamental components necessary for a comprehensive analysis of

existing achievements and identifying areas that require more in-depth study.

The primary task was to determine and systematize the collected data array, necessitating tools capable of handling and analyzing large volumes of information. SPSS was chosen for statistical analysis, having proven itself in the academic arena thanks to a wide array of procedures, including descriptive statistics, correlation studies, regression analysis, and visualization tools. By employing SPSS, it is possible to discern hidden patterns, distributions, and interrelationships within the data structure, as well as assess the statistical significance of the results obtained.

This tool ensures a comprehensive approach: from basic descriptive operations and frequency table construction to algorithmic trend identification using artificial intelligence methods. Such a broad range of technical solutions aims to produce highly reliable and reproducible results, allowing for the determination of key factors influencing the efficiency of early neurological diagnosis and for comparing and integrating data from diverse sources and regions.

The initial step involved forming a sample through a detailed search of scholarly publications based on specified keywords in the database, along with recording parameters such as year of publication, document type, and assignment to a particular journal or conference edition. After selection, duplicate entries were removed and irrelevant results inconsistent with the research subject were excluded. The publications were then systematized in an electronic database suitable for subsequent statistical and content analysis. At the first stage, descriptive statistics were evaluated using SPSS: determining the average number of publications per year, identifying periods of most intense

Results

In recent years, brain imaging has been rapidly evolving, enabling a significant increase in accuracy and timeliness when diagnosing diseases associated with neurodegeneration and cognitive impairments. Various methods, including MRI, PET, and DTI, make it possible to detect structural and functional changes that can appear long before clinical symptoms arise, which is particularly valuable when suspecting Alzheimer's disease (AD) and other forms of dementia [9-11]. A major breakthrough has been the use of fMRI and PET, as they allow for the detection of early metabolic shifts and cerebral blood flow anomalies [12]. At the same time, combining neuroimaging and cerebrospinal fluid biomarkers yields higher sensitivity and specificity in diagnosing MCI and AD [13], while the use of machine learning algorithms helps identify subtle data patterns, increasing diagnostic accuracy [10,14]. In pediatrics, DTI has greatly simplified the localization of epileptogenic foci, which is especially important in cases of treatment-resistant epilepsy [15], and assessing malignant neoplasms in childhood has become more detailed and timely [16]. Despite advancements, questions remain regarding the accessibility and high costs of technologies, as well as the risk of false positives, complicating clinical decision-making [17]. Nonetheless, the further integration of nanotechnology and artificial intelligence into image analysis [18,9,10,14] promises even earlier detection of neurological pathologies and more effective monitoring of their progression in the context of contemporary early diagnostic methods.

In addition to neuroimaging, the application of AI systems capable of analyzing large volumes of heterogeneous medical data significantly influences improvements in

growth, and analyzing various types of works in terms of their contribution to the data set. Concurrently, the distribution by journals and conference materials was studied to identify the outlets most frequently publishing results on neurology and diagnosis. Subsequently, an in-depth analysis was carried out: frequency tables were compiled, and regression models were constructed to trace changes in the scientific landscape. Where necessary, qualitative analysis of texts was applied to refine the findings and unveil thematic patterns.

In this process, keywords, phrases, and contextual indicators were coded, enabling a more precise definition of scientific directions, approaches, and methodological features. Visualization of results, including the creation of informative charts and graphs, facilitated interpretation and synthesis of the core findings. Ultimately, based on the analysis, a synthesized report was prepared, integrating all collected and examined data to form the basis of the scientific article.

Hence, the chosen approach encompassing thorough screening and systematization of materials, the use of multipurpose analytical tools, and a step-by-step data processing procedure ensures the comprehensiveness and reliability of the outcomes. Each phase, from sample formation to integrated analysis in SPSS and detailed study of textual sources, is oriented toward constructing the most accurate picture of the key aspects of early neurological diagnosis. This methodology guarantees reproducibility and a high level of scientific validity, while also opening up broad prospects for further in-depth research and the development of new strategies, ultimately contributing to enhancing early diagnostic practices and improving the quality of patient care.

diagnostic quality and speed. These solutions extend not only to oncology or cardiology [19,20] but also to dentistry [21] and emergency medicine, where machine learning helps detect critical conditions such as acute appendicitis [22]. Furthermore, deep neural networks and CNNs have proven effective in processing brain images, facilitating more accurate determination of tumor characteristics and staging [23]. However, these innovations face challenges including insufficient standardization of algorithms and limited reliability of certain results [24,25]. It is also crucial for clinicians to understand the logic behind neural network decisions, prompting growing interest in the concepts of explainable artificial intelligence [26]. It is worth emphasizing that in situations requiring a rapid response, intelligent systems can significantly reduce the time needed to make a diagnosis, and therefore initiate therapy earlier [27]. Although the requirement for large data volumes and privacy concerns remain unresolved [28], the potential for AI integration into the diagnostic process looks promising, especially given the increasing number of studies on early detection of oncological and neurological pathologies [29].

Thus, the combination of modern imaging methods, AI systems, and biomarker technologies provides a comprehensive basis for more accurate and timely diagnosis of neurological diseases, ensuring early detection of pathological processes and a personalized approach to treatment. Uniting these methods not only expands clinical practice capabilities but also optimizes patient routing, thereby increasing the effectiveness of therapeutic interventions. Despite existing constraints, including access to high-tech equipment, specialist training issues, and regulatory aspects, continued progress in this area

opens up new horizons for fundamental research and the implementation of innovations on a global scale.

A multifaceted analysis demonstrated the importance of a comprehensive approach encompassing an assessment of publication activity by year, a comparative review of scientific contributions from various countries, and an examination of the knowledge domains in which research is actively developing. Particular attention was devoted to the work of leading organizations and the identification of key journals, whose pages host the most significant studies. Further exploration of publication titles by keywords allowed for formulating the main directions of development and highlighting dominant thematic focuses, while citation analysis pinpointed works with the greatest authority and influence on the scientific discourse. The sum of the data obtained reflects characteristic trends and

consolidates promising avenues for future research and the practical application of findings.

An examination of the number of publications per year, starting from 1946 up to 2024, points to a gradual yet uneven evolution of interest in the subject matter. In the early period (1946-1970), the number of works was minimal, explained by both the limited volume of scientific research and the difficulties in accessing diagnostic technology at that time. Steady growth has been observed since the 1970s, but a notably sharp increase has occurred in more recent periods. For example, between 2005 and 2015, overall interest remained relatively stable, whereas from 2016 onward, it began to rise, reaching its highest values in 2024 (535 publications). This dynamic may reflect the emergence of new neuroimaging technologies and the improvement of AI tools for early diagnostics (Figure 1).

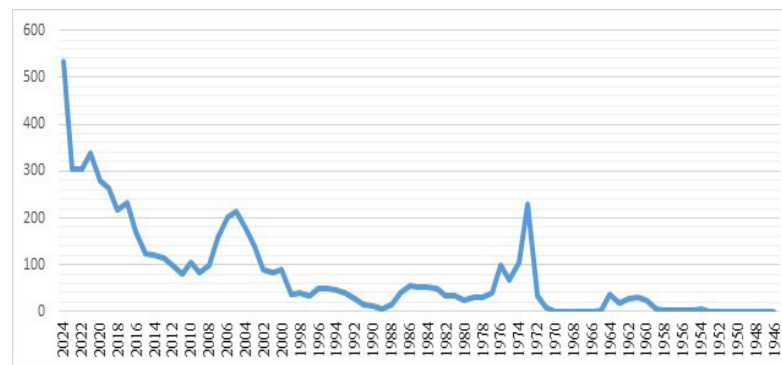


Figure 1 - Dynamics of publication activity on contemporary methods of early diagnosis of neurological diseases (1946–2024)
(Source: Authors' calculations based on Scopus-indexed publication data)

Since 2020, when many studies began emphasizing interdisciplinary approaches and the integration of genetic, biomarker, and IT technologies, the number of publications has grown even more rapidly. The shift toward new diagnostic standards and the increase in multinational projects likely played a key role in reaching the peak values in 2023 (303) and 2024 (535). These trends confirm the growing recognition of the importance of early detection of neurological pathologies, fueling further advances in optimizing diagnostics, refining instruments, and expanding the evidence base.

A comparative assessment of scientific activity by

country reveals substantial differences in the number of publications. The United States leads with 1781, followed by the United Kingdom (633) and Germany (487). China's significant contribution (387) highlights the rising role of the Asian region in contemporary scientific research. India (346) and Italy (272) also show high levels of interest, reflecting these countries' significant involvement in addressing issues related to early detection and monitoring. France (255), Canada (244), Japan (208), and Australia (194) round out the top ten, forming a picture of global scientific collaboration (Figure 2).

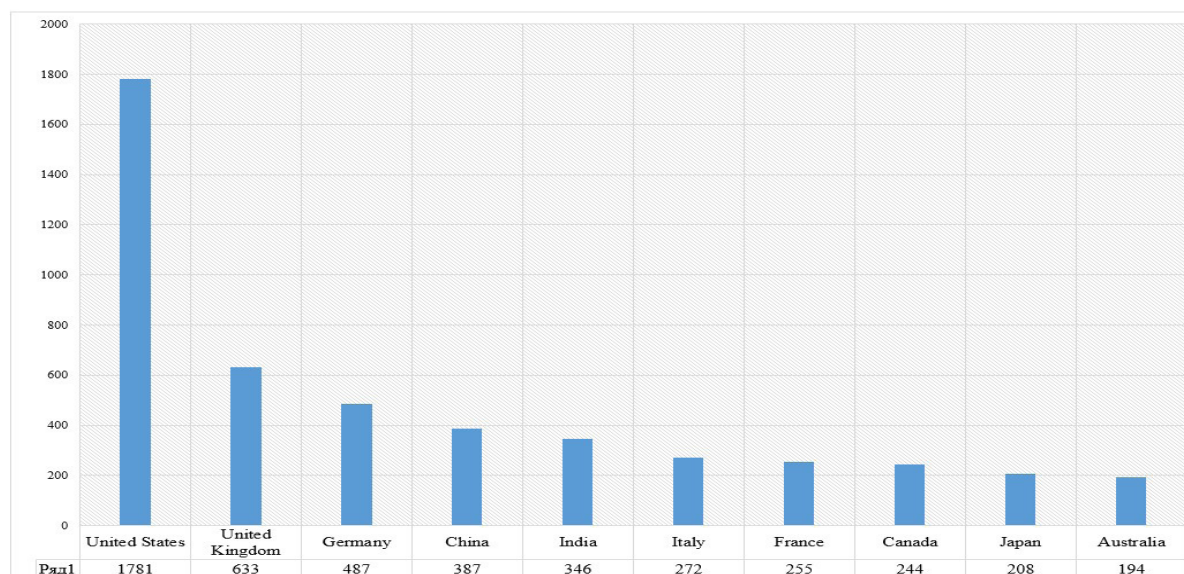


Figure 2 - Top 10 countries by number of publications on contemporary methods of early diagnosis of neurological diseases: analysis of Scopus data (Source: Authors' calculations based on Scopus-indexed publication data)

Next comes a range of countries with fewer studies, such as the Russian Federation (113), Turkey (119), and Brazil (99). Their contributions demonstrate the expansion of the international research field and highlight the importance of a multidisciplinary approach that takes into account regional aspects and healthcare resources. The geographic spread underscores broad recognition of the problem and confirms the considerable potential for further interstate exchange of experience and joint developments.

A preliminary distribution of publications by field of knowledge shows a clear dominance of medicine (4536), indicating the fundamental role of clinical and epidemiological research in this scientific domain. Following

are engineering (1067), computer science (1010), and neuroscience (838), whose high activity may be explained by the growing use of technologies, machine learning methods, and neuroimaging in the diagnostic process. Biochemistry, genetics and molecular biology (450), alongside the health professions (370), also demonstrate substantial academic interest, encompassing comprehensive approaches to early detection of diseases. Lesser but still notable attention is directed to the exact and natural sciences, including physics and astronomy (309), mathematics (270), and materials science (204), where computational models, statistical methods, and cutting-edge diagnostic materials are increasingly being employed (Figure 3).

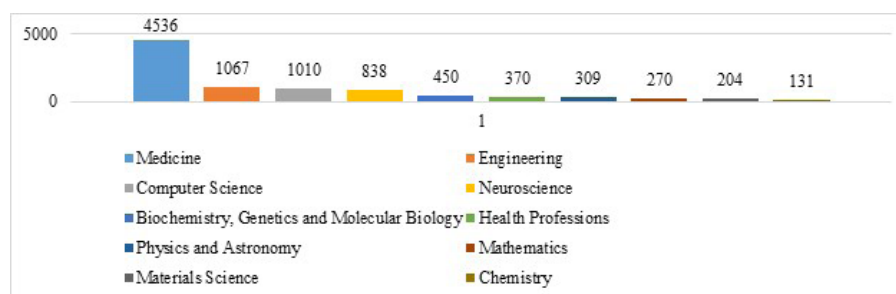


Figure 3 - Top 10 knowledge domains by number of scientific publications on contemporary methods of early diagnosis of neurological diseases: analysis of Scopus data
(Source: Authors' calculations based on Scopus-indexed publication data)

In a second cluster of fields, chemistry (131) and chemical engineering (106) stand out, reflecting the contribution of analytical and technological solutions, including the development of contrast agents and biosensors. The arts and humanities, as well as psychology (89 each) and the social sciences (79), though fewer in number, point to an interest in the ethical, cultural, and behavioral aspects of diagnosis. Moreover, economic factors (Business, Management and Accounting, 11), environmental considerations (Environmental Science, 44), and even veterinary medicine (Veterinary, 53) are increasingly taken into account in solving diagnostic challenges, underscoring the potential for multidisciplinary collaboration to improve the quality and timeliness of detection.

A comparison of research activities by different organizations shows a notable lead by Harvard Medical School (109 publications), followed by Massachusetts

General Hospital (108). The University of California, San Francisco (63) and the Mayo Clinic (60) play a significant role in shaping the scientific agenda, collectively reflecting a high level of expertise and professional standards in clinical research. Also included in the top ten most productive institutions are the UCL Queen Square Institute of Neurology (56) and University College London (55), confirming the international recognition of London-based research centers. Leading positions of the University of Toronto (53), along with the parallel success of Ludwig-Maximilians-Universität München (45) and UCSF School of Medicine (45), attest to broad geographic coverage and the substantial role of multinational projects in early diagnostics. Johns Hopkins University School of Medicine (43) and King's College London (43) complete the top group, representing prominent academic institutions with longstanding traditions of scientific discovery (Figure 4).

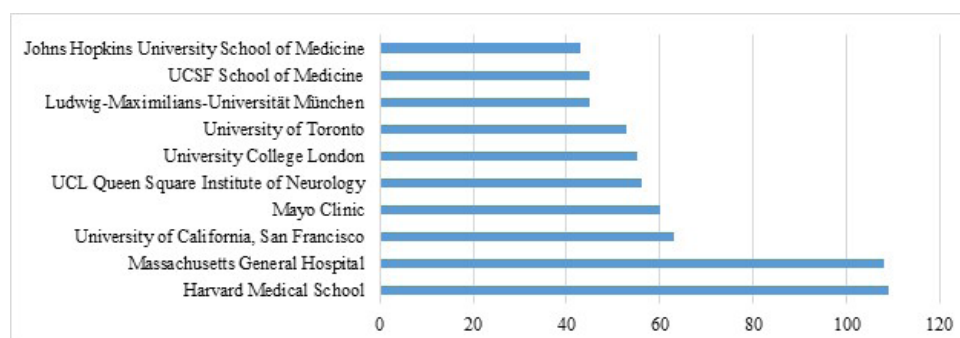


Figure 4 - Top 10 organizations by number of scientific publications on contemporary methods of early diagnosis of neurological diseases: analysis of Scopus data
(Source: Authors' calculations based on Scopus-indexed publication data)

Further analysis reveals active participation by the University of Pennsylvania (39), the VA Medical Center (38), and several medical schools such as UT Southwestern Medical Center (33) and Northwestern University Feinberg School of Medicine (32), indicating numerous clinical and laboratory studies. Concurrently, large research centers in Europe and

Asia Inserm (36), Brigham and Women's Hospital (36), the Chinese Academy of Sciences (24), and Capital Medical University (23) show a high level of engagement.

This trend underscores a rising interest in interdisciplinary collaboration and multinational projects aimed at developing and implementing more effective early detection methods for neurological disorders.

An analysis of scientific journals publishing works related to this topic indicates a clear dominance of BMJ Case Reports (434 publications). Neurology (108) also shows high figures, reflecting its leading role in discussing clinical and fundamental issues. Substantial venues for presenting research results include the Annual International Conference Of The IEEE Engineering In Medicine And Biology Proceedings (95), as well as the Lecture Notes In Computer

Science series (82), including subseries on artificial intelligence and bioinformatics. Among those consistently publishing relevant content are IEEE Transactions On Biomedical Engineering (71), Journal Of Neurology Neurosurgery And Psychiatry (57), Journal Of Neurology (44), and Archives Of Neurology (42), emphasizing a strong interest in specialized diagnostic issues. Other journals that occupy top positions include European Journal Of Radiology (39) and Progress In Biomedical Optics And Imaging Proceedings Of SPIE (39), demonstrating the major contribution of imaging technologies to research efforts (Figure 5).

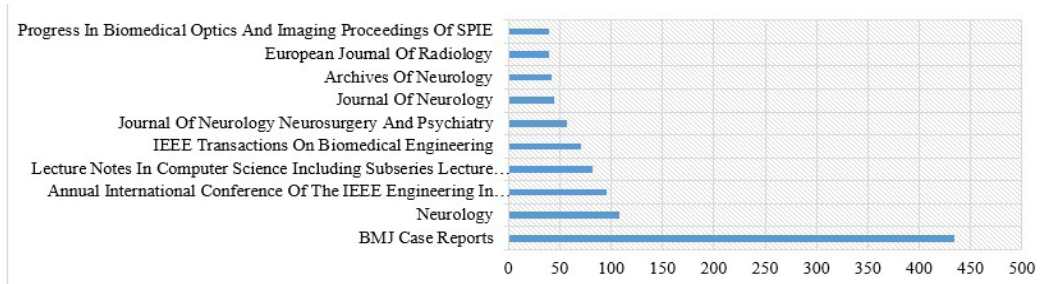


Figure 5 - Top 10 scientific journals by number of publications on contemporary methods of early diagnosis of neurological diseases: analysis of Scopus data (Source: Authors' calculations based on Scopus-indexed publication data)

The second wave of journals consists of those oriented toward innovative approaches and interdisciplinary research, such as Computers In Biology And Medicine (36), Journal Of Neural Engineering (35), and Optometry And Vision Science (35). The presence of IEEE Transactions On Medical Imaging (32), Computer Methods And Programs In Biomedicine (24), and Frontiers In Neurology (23) highlights the growing role of integrating computer algorithms, biomedical computing methods, and clinical data for early pathology detection. Publications in Meditsina Truda I Promyshlennaya Ekologiya (26) and Journal Of The Neurological Sciences (25) point to a multi-faceted research landscape that takes into account occupational factors and broadens the range of clinical scenarios. Such diversity in journals reflects both the deep specialization of individual areas and the drive toward interdisciplinary cooperation to optimize diagnostic strategies.

An analysis of the keywords found in the titles of scientific articles shows that the term "diagnosis" (650 mentions) ranks as one of the most frequently used, underscoring the priority placed on accurate and timely identification of pathologies. The terms "neurological" (545) and "neurology" (516) point to a clear focus on neurology, whereas "disease" (406) and "brain" (406) indicate researchers' concentration on specific mechanisms and clinical manifestations. The presence of words such as "clinical" (383), "epilepsy" (354), and "patients" (305) underscores the close link between theoretical models and practice, emphasizing the clinically oriented nature of the research. Equally significant are "analysis" (304) and "using" (397), which reflect the active application of analytical and computational methods in the processing of medical data (Table 1).

Table 1 - Top 20 keywords found in the titles of scientific publications on contemporary methods of early diagnosis of neurological diseases: analysis of Scopus data (Source: Authors' calculations based on the database of indexed articles in Scopus)

Keywords	Number of Keywords	Keywords	Number of Keywords
diagnosis	650	disorders	283
neurological	545	system	259
neurology	516	case	256
disease	406	eeg	248
brain	406	detection	242
using	397	syndrome	241
clinical	383	study	229
epilepsy	354	based	211
patients	305	diagnostic	208
analysis	304	imaging	197

Citation trends of the most authoritative works in the field of early diagnosis of neurological diseases clearly demonstrate that the leading publications receive broad recognition in the scientific community. At the top, "Heart rate variability: A review" (Acharya, U.R., Joseph, K.P., Kannathal, N., Lim, C.M., Suri, J.S., 2006) has 2092 mentions, followed by "Prediction of central nervous system embryonal tumour outcome based on gene expression"

(Pomeroy, S.L., Tamayo, P., Gaasenbeek, M., ... Lander, E.S., Golub, T.R., 2002) with 2051 citations. These figures indicate high demand for the results of both fundamental and clinical studies related to heart rate variability assessment and molecular-genetic approaches in diagnosing oncological pathologies of the central nervous system. Classic studies, such as "A continuous performance test of brain damage" (Rosvold, H.E., Mirsky, A.F., Sarason, I. et al., 1956) with

1770 citations, and work on developing diagnostic criteria for paraneoplastic neurological syndromes (Graus, F.,

Delattre, J.Y., Antoine, J.C. et al., 2004) with 1383 references, underscore long-standing interest in cognitive function.

Table 2 - Top 10 most cited works in the field of contemporary methods of early diagnosis of neurological diseases: analysis of Scopus data from 1946 to 2024 (Source: Authors' calculations based on the database of indexed articles in Scopus; Export Date: 26 December 2024)

Title of the Work	Authors	Source	Year	Citations
Heart rate variability: A review	Acharya, U.R., Joseph, K.P., Kannathal, N., Lim, C.M., Suri, J.S.	Medical and Biological Engineering and Computing, 44(12), 1031–1051. https://doi.org/10.1007/s11517-006-0119-0	2006	2 092
Prediction of central nervous system embryonal tumour outcome based on gene expression	Pomeroy, S.L., Tamayo, P., Gaasenbeek, M., ... Lander, E.S., Golub, T.R.	Nature, 415(6870), 436–442. https://doi.org/10.1038/415436a	2002	2 051
A continuous performance test of brain damage	Rosvold, H.E., Mirsky, A.F., Sarason, I., Bransome Jr., E.D., Beck, L.H.	Journal of Consulting Psychology, 20(5), 343–350. https://doi.org/10.1037/h0043220	1956	1 770
Recommended diagnostic criteria for paraneoplastic neurological syndromes	Graus, F., Delattre, J.Y., Antoine, J.C., ... Vincent, A., Voltz, R.	Journal of Neurology, Neurosurgery and Psychiatry, 75(8), 1135–1140. https://doi.org/10.1136/jnnp.2003.034447	2004	1 383
The relation of the Trail Making Test to organic brain damage	Reitan, R.M.	Journal of Consulting Psychology, 19(5), 393–394. https://doi.org/10.1037/h0044509	1955	1 380
Deep convolutional neural network for the automated detection and diagnosis of seizure using EEG signals	Acharya, U.R., Oh, S.L., Hagiwara, Y., Tan, J.H., Adeli, H.	Computers in Biology and Medicine, 100, 270–278. https://doi.org/10.1016/j.combiomed.2017.09.017	2018	1 242
Early, accurate diagnosis and early intervention in cerebral palsy: Advances in diagnosis and treatment	Novak, I., Morgan, C., Adde, L., ... White, R., Badawi, N.	JAMA Pediatrics, 171(9), 897–907. https://doi.org/10.1001/jamapediatrics.2017.1689	2017	1 072
An essay on the shaking palsy. 1817.	Parkinson, J.	The Journal of neuropsychiatry and clinical neurosciences, 14(2), 223–236. https://doi.org/10.1176/jnp.14.2.223	2002	1 007
A brain-computer interface using electrocorticographic signals in humans	Leuthardt, E.C., Schalk, G., Wolpaw, J.R., Ojemann, J.G., Moran, D.W.	Journal of Neural Engineering, 1(2), 63–71. https://doi.org/10.1088/1741-2560/1/2/001	2004	938
Wernicke's encephalopathy: new clinical settings and recent advances in diagnosis and management	Sechi, G., Serra, A.	Lancet Neurology, 6(5), 442–455. https://doi.org/10.1016/S1474-4422(07)70104-7	2007	913

A second tier of significant research focuses on implementing groundbreaking technologies and innovations into the diagnostic process. Among these, “Deep convolutional neural network for the automated detection and diagnosis of seizure using EEG signals” (Acharya, U.R., Oh, S.L., Hagiwara, Y. et al., 2018) with 1242 citations underlines the strategic importance of machine learning in EEG analysis. Equally notable attention is given to works on the early detection of cerebral palsy (Novak, I., Morgan, C., Adde, L. et al., 2017) and the historical foundations of neurology, such as “An essay on the shaking palsy. 1817.” (Parkinson, J., 2002). The final positions in the top ten are occupied by studies on brain-computer interface technology (Leuthardt, E.C., Schalk, G., Wolpaw, J.R. et al., 2004) and the diagnosis of encephalopathies (Sechi, G., Serra, A., 2007), highlighting the interdisciplinary nature of research and the particular relevance of improving diagnostic methods in neurology.

Thus, the overall analysis shows that interest in the early diagnosis of neurological diseases is increasing both

Discussion

The aim was to conduct a multifaceted analysis of publications focusing on the early diagnosis of neurological diseases and to identify the key trends, active research areas, and the most influential scientific teams and journals. To achieve this goal, a series of tasks was undertaken to gather and systematize data spanning temporal, geographical, and thematic dimensions, along with analyses of journals, organizations, keywords, and the most frequently cited works.

The results indicate a significant increase in publication activity over recent years, pointing to intensifying interest in enhancing methods for early detection of neurological disorders. The most active entities

quantitatively and qualitatively, covering a wide range of scientific fields and organizations worldwide. The revealed trends underscore a high level of international cooperation, the active introduction of cutting-edge technologies such as neuroimaging and AI, and the rising role of multidisciplinary approaches in research strategies. Special attention is paid to integrating biomarkers, neurophysiological methods, and computer algorithms for more accurate and timely detection of pathologies. The structure of publication activity, the geographic distribution of authors and key organizations, as well as an analysis of the most cited works, reveal a growing consensus in the scientific community regarding the importance and promise of improving diagnostic methods. This dynamic opens up extensive opportunities for continued research and the development of innovative methodological solutions that can substantially increase diagnostic efficiency and enhance patient outcomes.

turned out to be research groups in the United States, the United Kingdom, and several European countries, as well as universities and medical centers that adopt a multidisciplinary approach. This trend is driven by both the development of technological solutions, including neuroimaging and digital algorithms, and increased attention to neurodegenerative diseases and the search for effective prevention strategies.

An analysis of the fields to which publications belong shows sustained interest in medicine, engineering, computer science, and neurobiology. Although research in the humanities and socioeconomic areas is present in smaller volumes, it emphasizes the need for a holistic

examination of early diagnosis issues, encompassing not only clinical and technical factors but also social, cultural, and ethical considerations. Moreover, highly cited works often concentrate on the development and implementation of biomarkers, machine learning for processing electrophysiological signals, and the standardization of screening protocols.

A key outcome of the conducted analysis is the realization that despite evident progress in the creation and application of various early diagnostic methods, a number of major obstacles persist regarding their universal adoption. On the one hand, advanced tools, including neuroimaging, computational methods, and AI-based algorithms, indeed demonstrate high efficiency and flexibility in clinical practice, allowing specialists to identify potential neurological disorders more accurately and swiftly. On the other hand, such technologies typically require expensive equipment, qualified personnel, and a well-established infrastructure, limiting their widespread use particularly in regions with limited resources and uneven access to medical care. Meanwhile, growing international collaboration reveals opportunities for sharing best practices and leveling the playing field between medical facilities and research teams across different countries. Joint efforts and the establishment of a unified research platform not only improve diagnostic quality and accelerate the exchange of methodologies but also boost overall scientific potential: attracting specialists from various disciplines and regions of the world fosters diversity of perspectives and stimulates

Conclusion

This study has made it possible to identify a set of key regularities and trends associated with implementing contemporary methods of early diagnosis of neurological diseases. The analysis showed that a combination of technological solutions from neuroimaging and genetic sequencing to machine learning algorithms constitutes a robust foundation for more accurate and timely identification of pathologies. Consideration of publication activity, the geographical distribution of research, and the most frequently cited works has made it possible to outline the most promising directions and emphasize the role of a multidisciplinary approach in shaping a suite of diagnostic tools.

The findings confirm a growing interest in integrating innovative technologies into routine clinical practice. A notable achievement is the formation of an international collaborative network where scientific teams from different countries and disciplines contribute to developing and testing new methodologies.

This provides access to a wide range of resources and expertise, facilitating rapid adaptation and improvement of existing diagnostic protocols. At the same time, significant challenges remain regarding the standardization of clinical guidelines, expansion of infrastructure, and training specialists who can effectively apply new tools.

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new ideas to enhance diagnostic algorithms, standards, and protocols.

Moving forward, special attention should be paid to the synthesis of comprehensive interdisciplinary approaches, in which the integration of advanced technologies (neuroimaging, machine learning, biomarker analysis) and clinical protocols adapted to regional and economic realities plays a central role. Plans call for creating data-sharing platforms capable of unifying the results of diverse research efforts, thereby helping to standardize diagnostic criteria and increase predictive accuracy. In education and workforce training, it is essential to develop programs aimed at building competencies in computational, biomedical, and clinical disciplines, as well as proficiency in using contemporary data analysis tools.

Further, collaboration between universities, medical organizations, and industry sectors should be strengthened to speed the implementation of innovative technologies in practice and optimize costs. Expanding the availability of diagnostic technologies via telemedicine and mobile solutions, as well as creating cloud services for large-scale data analysis, has the potential to substantially reduce disparities in healthcare delivery. Such a comprehensive approach helps form a global scientific and practical network capable of providing more rapid and accurate detection of neurological diseases, thereby improving prognosis and quality of life for patients worldwide.

Ultimately, the analysis supports the argument that a holistic solution comprising technological innovations, well-structured research programs, expanded educational initiatives, and the creation of a unified information framework is needed. Overcoming barriers related to funding, accessibility, and standardization appears feasible through the expansion of international consortia, open databases, and the active deployment of telemedicine services.

This strategy not only advances the quality of early neurological disease detection but also promises to improve overall healthcare levels, thus presenting opportunities for further progress in understanding brain processes and refining therapeutic strategies.

Conflict of interests. The author declares no conflict of interest.

Funding. This research did not receive funding from any public, commercial, or non-profit organizations.

Author contribution. All stages of the study, including conceptualization, conducting the research, methodology development, data collection, original draft preparation, visualization, project administration, editing, and final supervision, were carried out by a single author – N.K.

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Неврологиялық ауруларды ерте диагностикалаудың заманауи әдістері: Халықаралық зерттеу тәжірибесі

[Косжанов Н.](#)

Жоғары санатты дәрігер-невролог, Via Medical көпсалалы медициналық орталығы,
Алматы, Қазақстан. E-mail: nurlan.nauka@gmail.com

Түйіндеме

Ғылыми зерттеулердің едәуір өсуі нейроимажинг, жасанды интеллект, биомаркерлерді зерттеу саласындағы жетістіктер ықпал еткен неврологиялық ауруларды ерте анықтауға қызығушылықтың артқанын көрсетеді.

Шолудың мақсаты диагноз қоюдың дәлдігі мен уақтылылығын арттыратын негізгі үрдістер мен инновациялық тәсілдерді анықтау, сондай-ақ неврологиялық бұзылулардың бастапқы сатысындағы пациенттер үшін болжамды жақсарту болып табылады.

Әдістері. Зерттеу бағытындағы мақалалар «Диагностика» және «Неврология» түйін сөздері бойынша таңдап алынып, нәтижесінде іріктелген 6132 ғылыми басылым SPSS бағдарламасын пайдалану арқылы статистикалық талдаудан өтті. Жылдар бойынша жарияланымдардың динамикасын зерттеу үшін жетекші елдер, жетекші ұйымдар мен негізгі ғылыми бағыттар бойынша сипаттау статистикасының әдісі қолданылды.

Нәтижелері. Талдау нәтижелері соңғы он жылдықта, әсіресе медицинада, машина жасауда, информатика саласында зерттеу еңбектері санының айтарлықтай өскенін анықтады. АҚШ бұл бағыттағы басылымдар саны бойынша жетекші орындарды иеленеді, одан кейін Ұлыбритания мен Германия. Көп салалы зерттеулер қазіргі заманғы нейроимажинг тәсілдерінен бастап, клиникаға дейінгі кезеңде нейродегенеративті және танымдық бұзылуларды анықтау үшін қолданылатын жасанды интеллект алгоритмдеріне дейінгі инновациялық технологиялардың пайда болуына ықпал етті.

Қорытынды. Ғылыми зерттеулер белсенділігіне жүйелі шолу неврологиялық ауруларды ерте диагностикалауға жаһандық қызығушылықтың артып келе жатқанын растайды. Технологиялардың жоғары құны және қолжетімділігі сияқты кедергілерге қарамастан, нейроимажинг, жасанды интеллект жүйелері мен биомаркерлердің интеграциясы диагностиканың дәлдігін арттыруға, халықаралық ынтымақтастықты дамытуға және неврология саласындағы ғылыми мүмкіндіктерді кеңейтуге зор әлеуетке ие.

Түйін сөздер: неврология, ерте диагностика, нейроимажинг, биомаркерлер, Scopus, статистикалық талдау.

Современные методы ранней диагностики неврологических заболеваний: Международный опыт исследований

[Косжанов Н.](#)

Врач-невролог высшей категории, Многопрофильный медицинский центр Via Medical, Алматы, Казахстан.
E-mail: nurlan.nauka@gmail.com

Резюме

Значительный рост научных работ свидетельствует об усилении интереса к раннему выявлению неврологических заболеваний, чему способствуют прогресс в нейровизуализации, искусственном интеллекте и исследованиях биомаркеров.

Цель обзора – выявить основные тенденции и инновационные подходы, повышающие точность и своевременность диагностики, а также улучшающие прогноз для пациентов на ранних стадиях неврологических нарушений.

Методы. Исследовательские статьи были отобраны по ключевым словам «Диагностика» и «Неврология», в результате чего отобранные 6132 научные публикации прошли статистический анализ с использованием программы SPSS. Для изучения динамики публикаций по годам применялся метод описательной статистики с учетом ведущих стран, ведущих организаций и основных научных направлений.

Результаты. Анализ показал существенный рост числа работ за последнее десятилетие, особенно в медицине, инженерии и компьютерных науках. Лидирующие позиции по количеству научных публикаций занимают США, за которыми следуют Великобритания и Германия. Мультидисциплинарные исследования способствовали появлению инновационных технологий от современных методов нейровизуализации до алгоритмов искусственного интеллекта, применяемых для обнаружения нейродегенеративных и когнитивных расстройств на доклинических стадиях.

Выводы. Системный обзор научной активности подтверждает рост мирового интереса к ранней диагностике неврологических заболеваний. Несмотря на существующие барьеры в виде высокой стоимости и доступности технологий, интеграция нейровизуализации, систем искусственного интеллекта и биомаркеров обладает большим потенциалом для повышения точности диагностики, развития международного сотрудничества и расширения научных горизонтов в неврологии.

Ключевые слова: неврология, ранняя диагностика, нейровизуализация, биомаркеры, Scopus, статистический анализ.