Parkinson's Disease: A Comprehensive Review

[1]Vasudevan Ranganathan, [2]Vinod Kumar
[1,2]Department of Biotechnology, Aurora's Degree & PG College

***Abstract*—Parkinson's disease (PD) is a progressive neurodegenerative disorder and one of the most common movement disorders affecting millions of individuals worldwide. Characterized by the degeneration of dopaminergic neurons in the substantia nigra and the accumulation of α-synuclein-containing Lewy bodies, PD manifests through a combination of motor symptoms, including tremor, rigidity, bradykinesia, and postural instability, as well as a wide range of non-motor symptoms that significantly impact quality of life. The incidence and prevalence of Parkinson's disease have increased globally over recent decades, largely due to population aging, improved diagnostic capabilities, and environmental and genetic influences. This comprehensive review examines the current understanding of Parkinson's disease, focusing on its epidemiology, pathophysiology, risk factors, clinical manifestations, diagnostic approaches, and therapeutic strategies. Genetic susceptibility, environmental exposures, oxidative stress, mitochondrial dysfunction, and neuroinflammation are explored as key contributors to disease development and progression. The review also discusses advances in diagnostic techniques, including neuroimaging and biomarker research, which aim to facilitate earlier and more accurate detection. Current treatment modalities, such as pharmacological therapies, surgical interventions, and emerging disease-modifying approaches, are evaluated with respect to their efficacy and limitations. Furthermore, the growing global burden of PD and its associated socioeconomic challenges are highlighted, emphasizing the need for effective public health strategies and continued research. Despite significant progress in understanding the disease, important gaps remain regarding its etiology and long-term management. A multidisciplinary approach integrating clinical care, scientific innovation, and preventive measures is essential to improve patient outcomes and address the increasing impact of Parkinson's disease on healthcare systems worldwide.**

***Index Terms*—Parkinsons disease, neurogeneratory conditions, neurological disorder**

I. INTRODUCTION

Parkinson's disease (PD) is a chronic, progressive neurodegenerative disorder that primarily affects the motor system and represents the second most common neurodegenerative disease after

Alzheimer's disease. First described by James Parkinson in 1817 as the "shaking palsy," PD has since emerged as a major public health concern due to its increasing prevalence and significant impact on affected individuals, caregivers, and healthcare systems worldwide. The disease is characterized by the selective degeneration of dopaminergic neurons in the substantia nigra pars compacta of the midbrain, resulting in dopamine deficiency within the basal ganglia circuitry [1]. In addition to neuronal loss, the pathological hallmark of PD is the presence of Lewy bodies and Lewy neurites, intracellular aggregates primarily composed of misfolded α-synuclein protein. These neuropathological changes contribute to the development of both motor and non-motor symptoms that progressively worsen over time. The cardinal motor manifestations of Parkinson's disease include resting tremor, bradykinesia, muscular rigidity, and postural instability, all of which significantly impair mobility and functional independence [2]. However, growing evidence suggests that non-motor symptoms, such as cognitive decline, depression, anxiety, sleep disturbances, autonomic dysfunction, and sensory abnormalities, may precede the onset of motor symptoms and substantially affect patients' quality of life. The clinical heterogeneity of PD highlights the complexity of its underlying mechanisms and presents challenges for accurate diagnosis and effective disease management. Although the exact etiology of Parkinson's disease remains incompletely understood, it is widely recognized as a multifactorial disorder resulting from a complex interaction between genetic susceptibility and environmental factors. Several genes, including SNCA, LRRK2, PARKIN, PINK1, and DJ-1, have been implicated in familial and sporadic forms of the disease [3].

Environmental exposures, such as pesticides, heavy metals, and industrial toxins, along with aging, oxidative stress, mitochondrial dysfunction, neuroinflammation, and protein misfolding, are believed to contribute to disease pathogenesis. Advancements in molecular biology and neurogenetics have significantly improved understanding of these mechanisms, offering promising avenues for the development of novel therapeutic interventions. The global burden of Parkinson's disease has increased substantially over recent decades, largely due to population aging and improved life expectancy [4]. This rising incidence poses considerable socioeconomic challenges and underscores the need for effective prevention, early diagnosis, and innovative treatment strategies. Despite significant progress in symptomatic management through pharmacological and surgical approaches, no definitive cure or disease-modifying therapy is currently available. Therefore, continued research is essential to unravel the complex pathophysiology of PD and identify strategies capable of slowing or halting disease progression [5]. This comprehensive review aims to provide an overview of the epidemiology, pathogenesis, clinical manifestations, diagnostic approaches, and current as well as emerging therapeutic strategies for Parkinson's disease, highlighting recent advances and future directions in the field. In recent years, increasing attention has been directed toward the early stages and prodromal features of Parkinson's disease, as researchers seek to identify biomarkers and therapeutic targets before substantial neuronal loss occurs. Evidence suggests that pathological changes may begin years or even decades before the appearance of classical motor symptoms [6].

Early manifestations such as hyposmia (loss of smell), constipation, rapid eye movement (REM) sleep behavior disorder, depression, and autonomic dysfunction are now recognized as important indicators of disease progression. The Braak hypothesis proposes that α-synuclein pathology may originate in peripheral tissues, including the gastrointestinal tract and olfactory system, before spreading to the central nervous system through interconnected neural pathways [7]. Although this theory remains under investigation, it has significantly influenced current research on disease initiation and progression. Furthermore, advances in neuroimaging techniques, cerebrospinal fluid analysis, genetic screening, and blood-based biomarkers have improved the ability to detect pathological changes at earlier stages. These developments offer promising opportunities for the implementation of personalized medicine approaches and the development of disease-modifying therapies. In addition to clinical and biological challenges, Parkinson's disease imposes a substantial economic and social burden on patients, families, and healthcare systems [8]. Long-term treatment requirements, disability, loss of productivity, and the need for continuous caregiving contribute to increased healthcare expenditures and reduced quality of life. As the global population continues to age, the prevalence of Parkinson's disease is expected to rise significantly, particularly in low- and middle-income countries where healthcare resources may be limited. Consequently, a comprehensive understanding of the disease is essential for clinicians, researchers, policymakers, and public health professionals. Ongoing multidisciplinary research efforts aimed at elucidating the molecular mechanisms underlying neurodegeneration, improving diagnostic accuracy, and developing novel therapeutic interventions are critical for addressing the growing burden of Parkinson's disease and enhancing outcomes for affected individuals worldwide [9].

II. NEUROIMAGING AND BIOMARKER RESEARCH FOR PARKINSONS DISEASE

Neuroimaging and biomarker research have emerged as critical areas in Parkinson's disease (PD) investigation, offering valuable insights into disease pathophysiology, early diagnosis, progression monitoring, and therapeutic development. Traditionally, the diagnosis of Parkinson's disease has relied primarily on clinical evaluation and the identification of characteristic motor symptoms. However, because significant dopaminergic neuronal loss has already occurred by the time motor manifestations become evident, there is a growing need for objective tools capable of detecting the disease during its prodromal and early stages [10]. Advances in neuroimaging technologies and biomarker discovery have therefore become essential for improving diagnostic accuracy and facilitating the development of disease-modifying interventions. Among neuroimaging techniques, positron emission tomography (PET) and single-photon emission computed tomography (SPECT) have played a pivotal role in assessing dopaminergic function in the brain. Dopamine transporter (DAT) imaging using SPECT enables visualization of presynaptic dopaminergic neuron integrity and is widely used to differentiate Parkinson's disease from other movement disorders with similar clinical presentations. PET imaging provides detailed information regarding dopamine synthesis, receptor activity, glucose metabolism, and neuroinflammatory processes, thereby enhancing understanding of disease mechanisms [11]. Magnetic resonance imaging (MRI), although

traditionally used to exclude secondary causes of parkinsonism, has evolved considerably with the introduction of advanced modalities such as diffusion tensor imaging (DTI), susceptibility-weighted imaging (SWI), functional MRI (fMRI), and neuromelanin-sensitive MRI.

These techniques allow the visualization of microstructural alterations, iron accumulation, functional connectivity changes, and degeneration within the substantia nigra and related neural networks. Such findings contribute to improved disease characterization and may support earlier diagnosis. Biomarker research has focused on identifying measurable biological indicators that reflect the presence, severity, or progression of Parkinson's disease. Alpha-synuclein, the principal component of Lewy bodies, has received considerable attention as a potential biomarker [12]. Altered levels of total, oligomeric, and phosphorylated α-synuclein have been detected in cerebrospinal fluid (CSF), blood, saliva, and other biological samples. Although variability among studies remains a challenge, advances in highly sensitive assays have improved the detection of pathological α-synuclein aggregates. In addition, biomarkers associated with neurodegeneration, including neurofilament light chain (NfL), tau proteins, inflammatory cytokines, and oxidative stress markers, are being investigated for their diagnostic and prognostic value. Recent developments in molecular and genetic biomarkers have further expanded opportunities for precision medicine in Parkinson's disease. Mutations in genes such as SNCA, LRRK2, GBA, PARKIN, PINK1, and DJ-1 have been associated with increased disease susceptibility and may help identify individuals at risk before clinical symptoms develop [13]. Furthermore, transcriptomic, proteomic, metabolomic, and epigenetic analyses are generating comprehensive molecular profiles that may improve patient stratification and reveal novel therapeutic targets. Blood-based biomarkers are particularly attractive due to their accessibility, cost-effectiveness, and suitability for large-scale screening. Emerging technologies, including artificial intelligence and machine learning, are increasingly being applied to integrate neuroimaging findings with biomarker data, enhancing predictive accuracy and enabling more personalized disease management. Although no single biomarker has yet achieved sufficient sensitivity and specificity for routine clinical use, ongoing research continues to refine multimodal approaches that combine imaging, molecular, and genetic markers. Such advances hold significant promise for earlier diagnosis, improved monitoring of disease progression, and the development of effective disease-modifying therapies for Parkinson's disease [14].

III. CURRENT TREATMENT STRATEGIES FOR PARKINSONS DISEASE

The management of Parkinson's disease (PD) is primarily focused on alleviating symptoms, maintaining functional independence, and improving the quality of life of affected individuals. Despite significant advances in understanding the pathophysiology of the disease, no definitive cure or disease-modifying therapy currently exists. Therefore, current treatment approaches are largely symptomatic and involve a combination of pharmacological, surgical, rehabilitative, and supportive interventions tailored to the individual needs of patients. The choice of treatment depends on factors such as age, disease severity, symptom profile, comorbidities, and response to

previous therapies [15]. Early and comprehensive management is essential for optimizing long-term outcomes and minimizing complications associated with disease progression. Pharmacological therapy remains the cornerstone of Parkinson's disease treatment. Levodopa, a precursor of dopamine capable of crossing the blood–brain barrier, is considered the most effective medication for controlling motor symptoms such as bradykinesia, rigidity, and tremor. It is commonly administered in combination with peripheral dopa-decarboxylase inhibitors, such as carbidopa or benserazide, which enhance its bioavailability and reduce peripheral side effects. Although levodopa provides substantial symptomatic relief, prolonged use is frequently associated with motor fluctuations and dyskinesias, which can complicate disease management [16]. To address these limitations, additional medications are often used either as monotherapy in early disease or as adjunctive treatments in advanced stages.

Dopamine agonists, including pramipexole, ropinirole, and rotigotine, directly stimulate dopamine receptors and may delay the need for levodopa therapy in some patients. Monoamine oxidase-B (MAO-B) inhibitors, such as selegiline, rasagiline, and safinamide, reduce dopamine breakdown and provide modest symptomatic benefits. Catechol-O-methyltransferase (COMT) inhibitors, including entacapone and opicapone, prolong the action of levodopa by inhibiting its peripheral metabolism. Other agents, such as amantadine and anticholinergic drugs, may be used selectively to manage dyskinesias and tremor, respectively [17]. For patients with advanced Parkinson's disease who experience significant motor complications despite optimized medical therapy, surgical interventions may be considered. Deep brain stimulation (DBS) has become an established treatment option and involves the implantation of electrodes into specific brain regions, most commonly the subthalamic nucleus or globus pallidus interna. Electrical stimulation modulates abnormal neural activity, resulting in improved motor control, reduced medication requirements, and enhanced quality of life. In carefully selected patients, DBS can provide substantial and sustained symptomatic benefits [18]. Emerging device-assisted therapies, including levodopa-carbidopa intestinal gel infusion and continuous subcutaneous apomorphine infusion, offer additional options for managing motor fluctuations in advanced disease. In addition to pharmacological and surgical treatments, multidisciplinary supportive care plays a crucial role in comprehensive disease management. Physical therapy helps maintain mobility, balance, flexibility, and muscle strength, while occupational therapy assists patients in adapting to daily activities and preserving independence [19]. Speech and language therapy can improve communication difficulties and swallowing dysfunction, both of which are common in advanced stages of the disease.

Psychological counseling and cognitive rehabilitation may be beneficial for addressing depression, anxiety, cognitive impairment, and other non-motor symptoms. Nutritional support, regular exercise, and patient education are also essential components of long-term care. Collectively, these treatment strategies aim to optimize symptom control, reduce disability, and enhance overall well-being, while ongoing research continues to explore novel therapies capable of slowing or halting disease progression [20].

IV. GROWING GLOBAL BURDEN OF PD

Parkinson's disease (PD) has emerged as one of the fastest-growing neurological disorders worldwide, representing a significant and increasing public health challenge. Over the past several decades, the prevalence and incidence of Parkinson's disease have risen substantially across both developed and developing countries. This increase has been attributed primarily to population aging, longer life expectancy, improved diagnostic awareness, and the growing influence of environmental and lifestyle factors associated with neurodegeneration. As age remains the strongest risk factor for Parkinson's disease, the expansion of elderly populations globally has contributed significantly to the rising number of affected individuals [21]. According to epidemiological studies, the global burden of PD has more than doubled since the 1990s, and projections suggest that the number of cases will continue to increase dramatically in the coming decades. This trend has led some researchers to describe Parkinson's disease as a potential "neurological pandemic" of the twenty-first century.

The impact of Parkinson's disease extends far beyond its clinical manifestations, affecting patients, families, healthcare systems, and national economies. Individuals living with PD experience progressive motor impairment, including tremor, rigidity, bradykinesia, and postural instability, which can severely limit mobility and independence. In addition, non-motor symptoms such as cognitive decline, depression, anxiety, sleep disturbances, autonomic dysfunction, and chronic pain contribute substantially to disability and reduced quality of life. As the disease progresses, many patients require long-term medical care, rehabilitation services, assistive devices, and support from caregivers. These increasing healthcares needs place considerable strain on healthcare resources and social support systems [22]. The economic burden of Parkinson's disease is equally substantial. Direct medical costs include expenditures related to physician consultations, diagnostic procedures, medications, hospitalization, surgical interventions such as deep brain stimulation, and long-term care services. Indirect costs arise from loss of productivity, early retirement, reduced work capacity, caregiver burden, and premature mortality. Family members often assume caregiving responsibilities, which may result in emotional stress, financial hardship, and diminished quality of life [23]. Consequently, the overall socioeconomic impact of Parkinson's disease extends beyond affected individuals and influences broader community and healthcare infrastructures. Geographical disparities further complicate the global burden of PD. While high-income countries generally have greater access to specialized neurological care, advanced diagnostic tools, and modern therapeutic options, many low- and middle-income countries face significant challenges in providing adequate healthcare services for Parkinson's disease patients [24].

Limited awareness, shortages of trained healthcare professionals, inadequate diagnostic facilities, and restricted access to medications contribute to delayed diagnosis and suboptimal management in these regions. As populations in developing countries continue to age, the burden of Parkinson's disease is expected to increase disproportionately, emphasizing the need for equitable healthcare

policies and resource allocation. Addressing the growing global burden of Parkinson's disease requires coordinated efforts involving healthcare providers, researchers, policymakers, patient advocacy organizations, and public health agencies [25]. Strategies aimed at improving early diagnosis, expanding access to treatment, promoting public awareness, supporting caregivers, and investing in research are essential for mitigating the disease's impact. Furthermore, ongoing investigations into disease-modifying therapies, neuroprotective interventions, and preventive measures offer hope for reducing future disease burden. As the prevalence of Parkinson's disease continues to rise worldwide, comprehensive and sustainable approaches will be necessary to improve patient outcomes and alleviate the significant social and economic challenges associated with this progressive neurodegenerative disorder [26].

V. PUBLIC HEALTH STRATEGIES

The increasing prevalence of Parkinson's disease (PD) worldwide has highlighted the need for comprehensive public health strategies aimed at reducing disease burden, improving patient outcomes, and ensuring equitable access to healthcare services. As a chronic and progressive neurodegenerative disorder, Parkinson's disease presents unique challenges that extend beyond clinical management and require coordinated efforts at local, national, and global levels. Effective public health approaches must integrate disease awareness, early detection, healthcare infrastructure development, patient support systems, research initiatives, and policy interventions to address the growing impact of PD on individuals and society. One of the most important public health priorities is increasing awareness and education about Parkinson's disease among both healthcare professionals and the general population [27]. Public awareness campaigns can help individuals recognize early symptoms, reduce stigma associated with neurological disorders, and encourage timely medical consultation. Similarly, continuing medical education programs for healthcare providers can enhance diagnostic accuracy and facilitate earlier intervention, which is essential for optimizing treatment outcomes and maintaining quality of life. Early diagnosis enables patients to access appropriate therapies, rehabilitation services, and support resources before significant disability develops. Strengthening healthcare systems is another critical component of Parkinson's disease management. Many regions, particularly low- and middle-income countries, face shortages of neurologists, movement disorder specialists, rehabilitation professionals, and diagnostic facilities [28]. Expanding healthcare infrastructure, improving workforce training, and integrating Parkinson's disease care into primary healthcare services can enhance accessibility and continuity of care. Telemedicine and digital health technologies have also emerged as valuable tools for delivering specialized care to underserved and remote populations, reducing geographical barriers and improving patient monitoring. Comprehensive multidisciplinary care should be promoted as a standard approach in Parkinson's disease management [29]. Public health policies should support access to pharmacological treatment, physical therapy, occupational therapy, speech therapy, mental health services, and nutritional counseling. Such integrated care models have been shown to improve functional outcomes, reduce

hospitalizations, and enhance patient well-being. In addition, caregiver support programs are essential, as family members often provide long-term assistance to individuals with Parkinson's disease. Educational resources, respite care services, and psychological support can help reduce caregiver burden and improve overall care quality [30].

Research and surveillance systems also play a crucial role in public health planning. Establishing national and international disease registries can facilitate the collection of epidemiological data, monitor disease trends, and identify high-risk populations. Increased investment in biomedical research is necessary to advance understanding of disease mechanisms, discover reliable biomarkers, and develop neuroprotective or disease-modifying therapies. Collaboration among academic institutions, healthcare organizations, government agencies, and patient advocacy groups can accelerate scientific progress and promote evidence-based healthcare policies [31].

Preventive strategies may also contribute to reducing future disease burden. Although the exact causes of Parkinson's disease remain incompletely understood, efforts to minimize exposure to environmental risk factors such as pesticides, industrial toxins, and air pollution may have potential public health benefits. Encouraging healthy lifestyles, including regular physical activity, balanced nutrition, cognitive engagement, and cardiovascular risk management, may support overall brain health and potentially lower the risk of neurodegenerative diseases [32]. Ultimately, effective public health strategies for Parkinson's disease require sustained commitment, multidisciplinary collaboration, and equitable resource allocation to ensure that individuals affected by the disease receive timely diagnosis, comprehensive care, and opportunities for improved quality of life while addressing the growing global burden of this complex neurological disorder. Furthermore, international cooperation and policy development are essential for addressing the global challenges posed by Parkinson's disease [33]. Governments and health organizations should prioritize the inclusion of neurological disorders within national health agendas and allocate adequate funding for patient care, rehabilitation services, and scientific research. Public-private partnerships can facilitate innovation in diagnostics, therapeutics, and healthcare delivery systems. Additionally, patient advocacy groups play a vital role in raising awareness, promoting education, supporting affected individuals, and influencing policy decisions. By fostering collaboration among stakeholders, healthcare systems can better respond to the increasing burden of Parkinson's disease and improve long-term patient outcomes [34].

VII. DISCUSSION

Parkinson's disease remains one of the most complex and rapidly growing neurodegenerative disorders worldwide, presenting substantial clinical, social, and economic challenges. The findings discussed throughout this review highlight the multifactorial nature of the disease and emphasize the need for a comprehensive understanding of its epidemiology, pathogenesis, diagnosis, and management. Although significant advances have been made in elucidating the molecular and cellular mechanisms underlying Parkinson's disease, many aspects of its etiology remain incompletely understood. The interaction between genetic susceptibility, environmental

exposures, aging, mitochondrial dysfunction, oxidative stress, neuroinflammation, and α-synuclein aggregation appears to contribute collectively to disease development and progression [35]. Continued investigation of these mechanisms is essential for identifying novel therapeutic targets and improving patient outcomes. One of the most important observations emerging from recent research is the increasing global burden of Parkinson's disease. The rising incidence and prevalence of PD, largely driven by population aging and increased life expectancy, have transformed the disorder into a major public health concern. The growing number of affected individuals is expected to place significant pressure on healthcare systems, particularly in low- and middle-income countries where access to specialized neurological care and rehabilitation services may be limited. These trends underscore the importance of developing effective healthcare policies, improving disease surveillance, and ensuring equitable access to diagnosis and treatment [36].

Advances in neuroimaging and biomarker research have significantly enhanced the understanding of Parkinson's disease and offer promising opportunities for earlier diagnosis and improved disease monitoring. Techniques such as dopamine transporter imaging, functional magnetic resonance imaging, and molecular biomarker analyses have demonstrated considerable potential in detecting pathological changes before the onset of overt motor symptoms. However, despite encouraging progress, no single biomarker has yet achieved sufficient sensitivity and specificity for routine clinical application. Future studies should focus on validating multimodal biomarker approaches that integrate imaging, genetic, proteomic, and biochemical data to improve diagnostic accuracy and facilitate personalized medicine [37]. Current treatment strategies have substantially improved symptom management and quality of life for many patients. Pharmacological therapies, particularly levodopa-based regimens, remain the gold standard for controlling motor symptoms, while surgical interventions such as deep brain stimulation provide effective options for selected patients with advanced disease. Nevertheless, existing treatments primarily address symptoms rather than the underlying neurodegenerative process. The absence of disease-modifying therapies represents a major limitation in current clinical practice and highlights the urgent need for continued therapeutic innovation [38].

Emerging approaches targeting α-synuclein aggregation, neuroinflammation, mitochondrial dysfunction, and genetic pathways offer potential avenues for altering disease progression. From a public health perspective, comprehensive strategies involving awareness programs, early detection initiatives, multidisciplinary care models, caregiver support, and increased research funding are critical for addressing the growing burden of Parkinson's disease. Collaboration among clinicians, researchers, policymakers, and patient advocacy organizations will be essential to translate scientific discoveries into meaningful clinical and societal benefits. Overall, while substantial progress has been achieved in understanding and managing Parkinson's disease, continued research and coordinated public health efforts are necessary to overcome existing challenges and improve the lives of individuals affected by this progressive neurological disorder [39].

VIII. CONCLUSION

Parkinson's disease is a progressive and multifactorial neurodegenerative disorder that continues to pose significant clinical and public health challenges worldwide. This comprehensive review highlights the complex nature of the disease, encompassing its epidemiology, pathophysiological mechanisms, clinical manifestations, diagnostic approaches, treatment strategies, and global burden. The increasing prevalence of Parkinson's disease, driven largely by aging populations and improved diagnostic recognition, underscores its growing importance as a major neurological condition of the twenty-first century. Despite extensive research, the exact etiology of Parkinson's disease remains incompletely understood. Current evidence strongly suggests that its development results from an intricate interplay between genetic predisposition and environmental influences, leading to neuronal dysfunction, α-synuclein aggregation, oxidative stress, mitochondrial impairment, and neuroinflammation. These pathological processes ultimately contribute to the degeneration of dopaminergic neurons in the substantia nigra, resulting in the characteristic motor and non-motor symptoms of the disease. The heterogeneity of clinical presentation further complicates early diagnosis and disease classification, emphasizing the need for improved diagnostic tools. Advances in neuroimaging and biomarker research have provided valuable insights into early disease detection and progression monitoring.

However, no single biomarker or imaging modality currently offers sufficient accuracy for routine clinical use. A multimodal approach combining clinical evaluation, imaging techniques, and molecular biomarkers appears to be the most promising direction for future diagnostics. Similarly, while pharmacological therapies such as levodopa and adjunctive agents remain highly effective in symptom management, they do not alter disease progression. Surgical interventions, including deep brain stimulation, offer additional benefits in advanced cases but are not suitable for all patients. The growing global burden of Parkinson's disease presents significant socioeconomic implications, particularly in resource-limited settings where access to specialized care is restricted. This necessitates the implementation of robust public health strategies, including early screening, awareness programs, multidisciplinary care models, and improved healthcare infrastructure. Additionally, caregiver support and rehabilitation services are essential components of comprehensive disease management. In conclusion, although significant progress has been made in understanding and treating Parkinson's disease, major gaps remain in achieving early diagnosis, disease modification, and prevention. Future research should focus on elucidating disease mechanisms, developing reliable biomarkers, and discovering neuroprotective therapies.

A collaborative and multidisciplinary approach integrating clinical practice, research innovation, and public health policy is essential to reduce the burden of Parkinson's disease and improve the quality of life for affected individuals globally.

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