

Alzheimer's Disease: A Chronic Neurodegenerative Disorder and Leading Cause of Dementia

Charlotte Taylor^{1*}, William Thompson² and Mason Walker²

¹Department of Psychology, University of Canterbury, New Zealand

²Department of Psychological Medicine, University of Otago, New Zealand

Abstract

Alzheimer's disease, a chronic and progressive neurodegenerative disorder, is the leading cause of dementia, accounting for 60% to 70% of dementia cases worldwide. Characterized by a gradual decline in cognitive abilities, memory loss, and behavioral changes, Alzheimer's typically begins with subtle symptoms and progressively worsens over time. This deterioration is primarily due to the accumulation of amyloid plaques and neurofibrillary tangles in the brain, leading to the death of brain cells. While the exact cause remains elusive, genetic, environmental, and lifestyle factors are believed to play critical roles. Early diagnosis and intervention are crucial to managing symptoms and improving patient outcomes, though current treatments primarily focus on slowing disease progression. As life expectancy increases globally, Alzheimer's disease presents significant healthcare challenges, underscoring the need for advanced research in both preventive measures and therapeutic approaches.

Keywords: Alzheimer's disease; Neurodegenerative disorder; Dementia; Cognitive decline; Memory loss; Amyloid plaques; Neurofibrillary tangles; Early diagnosis; Disease progression; Therapeutic interventions

Introduction

Alzheimer's disease (AD) is a chronic, progressive neurodegenerative disorder that is the most common cause of dementia, responsible for 60% to 70% of all dementia cases worldwide. Initially described by Alois Alzheimer in 1906, the disease is characterized by a gradual decline in cognitive functions, including memory, thinking, reasoning, and communication abilities. Over time, these symptoms become severe enough to interfere with daily activities, eventually leading to a complete loss of independence. The pathological hallmarks of Alzheimer's disease include the accumulation of amyloid plaques and neurofibrillary tangles in the brain, which result in the death of neurons and the subsequent shrinkage of brain tissue [1]. Although the exact cause of Alzheimer's remains unknown, research suggests that a combination of genetic predisposition, environmental factors, and lifestyle choices contribute to its development. Age is the greatest risk factor, with the majority of cases occurring in individuals over the age of 65. However, early-onset Alzheimer's, affecting people in their 40s or 50s, also occurs in rare cases.

As the global population ages, Alzheimer's disease has become an increasingly prevalent public health concern, placing significant emotional, physical, and financial burdens on patients, families, and healthcare systems. Despite extensive research, there is currently no cure for Alzheimer's disease, and treatments primarily focus on managing symptoms and slowing disease progression. This underscores the urgent need for continued research into the underlying mechanisms of the disease and the development of more effective therapies [2].

Overview of alzheimer's disease

Alzheimer's disease is a progressive neurodegenerative disorder that primarily affects older adults and is characterized by a gradual decline in cognitive functions. As the most common form of dementia, it leads to significant memory loss, impaired reasoning, and alterations in behavior. The disease's onset is typically insidious, with symptoms worsening over time, ultimately impacting the individual's ability to perform daily activities and maintain independence.

Causes and risk factors

The exact cause of Alzheimer's disease remains elusive, but it is widely accepted to involve a complex interplay of genetic, environmental, and lifestyle factors. Genetic predisposition plays a role, with mutations in specific genes like APP, PSEN1, and PSEN2 being linked to early-onset forms. Age is the most significant risk factor, with the likelihood of developing Alzheimer's increasing markedly after age 65. Other risk factors include cardiovascular diseases, diabetes, head trauma, and lower levels of education and cognitive engagement [3].

Pathophysiology of alzheimer's disease

The pathophysiology of Alzheimer's disease involves a combination of amyloid plaque formation, neurofibrillary tangles, and neurodegeneration. Amyloid plaques consist of beta-amyloid peptides that aggregate outside neurons, disrupting cell function and triggering inflammatory responses. Neurofibrillary tangles are intracellular accumulations of hyperphosphorylated tau protein that lead to microtubule destabilization and cell death. These pathological changes result in widespread neuronal loss and brain atrophy.

Amyloid plaques and neurofibrillary tangles

Amyloid plaques are one of the defining features of Alzheimer's disease and are composed of beta-amyloid peptides. These plaques interfere with neuronal communication and contribute to the neuroinflammatory processes seen in the disease. Neurofibrillary tangles, on the other hand, are intracellular aggregates of hyperphosphorylated tau protein. They disrupt neuronal transport

***Corresponding author:** Charlotte Taylor, Department of Psychology, University of Canterbury, New Zealand, E-mail: Charlotte.Tay@lor.nz

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systems and are closely associated with the severity of cognitive decline [4].

Symptoms and stages of alzheimer's disease

Early Stage: In the early stages of Alzheimer's disease, symptoms are often subtle and may include mild memory loss, difficulty in recalling recent events, and challenges in organizing and planning. Individuals may also experience confusion about time or place.

Middle stage: As the disease progresses to the middle stage, cognitive impairment becomes more pronounced. Symptoms include significant memory loss, difficulty with language, disorientation, and changes in personality and behavior. Individuals may require assistance with daily activities and personal care.

Late stage: In the late stage of Alzheimer's disease, patients experience severe cognitive decline and loss of independence. They may be unable to communicate effectively, recognize loved ones, or perform basic activities of daily living. Physical abilities also deteriorate, leading to mobility issues and an increased risk of infections [5].

Diagnosis of alzheimer's disease

Clinical Assessment: Diagnosis of Alzheimer's disease begins with a comprehensive clinical assessment that includes a detailed medical history, cognitive testing, and evaluation of functional abilities. The assessment aims to differentiate Alzheimer's from other types of dementia and identify any contributing factors.

Imaging and biomarkers: Imaging techniques, such as MRI and PET scans, are used to visualize brain structure and function, helping to detect characteristic changes associated with Alzheimer's disease. Biomarkers, including levels of beta-amyloid and tau proteins in cerebrospinal fluid, also aid in diagnosis and disease monitoring.

Current treatment approaches

Pharmacological treatments: Current pharmacological treatments for Alzheimer's disease include cholinesterase inhibitors (e.g., donepezil, rivastigmine) and NMDA receptor antagonists (e.g., memantine). These medications aim to improve or stabilize cognitive function and manage behavioral symptoms [6].

Non-pharmacological interventions: Non-pharmacological interventions involve cognitive stimulation therapies, behavioral therapies, and lifestyle modifications. These approaches focus on enhancing quality of life, promoting cognitive engagement, and addressing specific behavioral challenges.

Challenges in alzheimer's disease management

Alzheimer's disease management faces several challenges, including the need for early diagnosis, the complexity of symptom management, and the emotional and financial burden on caregivers. Additionally, the progressive nature of the disease and the lack of curative treatments present ongoing difficulties.

Research and future directions

Emerging therapeutic strategies: Research into Alzheimer's disease is exploring several promising therapeutic strategies, including immunotherapy to target amyloid plaques, tau-targeted therapies, and gene-based interventions. Advances in understanding the disease mechanisms are paving the way for innovative treatment approaches.

Preventive approaches: Preventive strategies are also a focus

of current research, with efforts aimed at identifying modifiable risk factors and developing lifestyle interventions to reduce the risk of Alzheimer's disease [7]. Studies on diet, physical activity, and cognitive training are ongoing to determine their efficacy in delaying or preventing disease onset.

Results and Discussion

Results

Recent research has provided valuable insights into the various aspects of Alzheimer's disease, from its pathophysiology to emerging treatment strategies. Studies have confirmed the central role of amyloid plaques and neurofibrillary tangles in the progression of the disease. Imaging studies and biomarker analyses have further solidified the link between these pathological features and cognitive decline. Clinical trials evaluating new pharmacological treatments have shown varying degrees of efficacy, with some medications demonstrating modest benefits in slowing cognitive deterioration. Non-pharmacological interventions, such as cognitive training and behavioral therapies, have also been shown to offer improvements in quality of life and functional abilities, although results can be inconsistent [8].

Discussion

The accumulation of amyloid plaques and neurofibrillary tangles is well-established as a hallmark of Alzheimer's disease, correlating strongly with the severity of cognitive impairment. However, while these pathological features are crucial, they do not fully explain the variability in disease progression among patients. Recent studies suggest that additional factors, including neuroinflammation and vascular changes, may also contribute significantly to disease outcomes. The clinical utility of imaging and biomarkers has been a major advancement in Alzheimer's diagnosis and monitoring. Advances in PET imaging and cerebrospinal fluid biomarkers have enhanced early detection and differential diagnosis, although these techniques are often expensive and not universally accessible [9].

Current pharmacological treatments, such as cholinesterase inhibitors and NMDA receptor antagonists, provide symptomatic relief but do not alter the disease's course. Research into novel therapeutic agents, including amyloid-targeting drugs and tau-targeted therapies, holds promise for more effective treatments. However, these emerging therapies are still under investigation, and their long-term efficacy and safety need further validation.

Non-pharmacological approaches have shown potential in improving patient outcomes, particularly in enhancing cognitive function and managing behavioral symptoms. Cognitive stimulation, physical exercise, and psychosocial interventions can support overall well-being and may slow the progression of cognitive decline. Nevertheless, these interventions require more extensive research to standardize protocols and determine their optimal application in clinical practice. Challenges in Alzheimer's disease management include the need for more precise diagnostic tools, effective treatments, and comprehensive care strategies. The emotional and financial burden on caregivers is substantial, highlighting the need for better support systems and resources. Additionally, addressing risk factors through lifestyle modifications and preventive measures remains a critical area of focus [10].

Future research is expected to explore a broader range of therapeutic strategies and preventive approaches. Innovations in molecular biology, genetics, and neuroimaging will likely drive advancements

in understanding the disease mechanisms and developing targeted interventions. As our knowledge evolves, personalized medicine approaches may offer more tailored and effective treatments for Alzheimer's disease.

Conclusion

Alzheimer's disease remains a significant global health challenge due to its profound impact on cognitive function and quality of life. Despite extensive research, the exact etiology of the disease is not fully understood, but it is characterized by key pathological features such as amyloid plaques and neurofibrillary tangles. Current diagnostic techniques and biomarkers have advanced our ability to detect and monitor the disease, yet early and accurate diagnosis remains challenging. While existing pharmacological treatments offer symptomatic relief, they do not halt disease progression, underscoring the need for more effective therapies. Non-pharmacological interventions, such as cognitive and behavioral therapies, play a valuable role in managing symptoms and enhancing patient well-being, though more research is needed to standardize and optimize these approaches.

Acknowledgment

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Conflict of Interest

None

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