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INTRODUCTION

Alzheimer's disease is a debilitating brain disorder that gradually destroys an individual's memory and thinking abilities, and eventually, their ability to carry out quotidian tasks. Alzheimer's is the most common manifestation of dementia amongst older populations. Typical symptoms include, but are not limited to, issues with thinking, remembering, reasoning, and an overall loss of behavioral abilities [1]. These cognitive impairments lead to a loss of function, and over time, will progressively interfere with an individual's everyday life.

Age is the biggest current risk factor for Alzheimer's, as less than 10% of documented cases and diagnoses occur before the age of 65 [1]. Additionally, the reach of chronic neurodegenerative conditions is on track to double within the next twenty years, given the world's aging population [1]. Research on brain aging continues to explore the reasoning behind this risk factor, and scientists are beginning to understand how age-related changes, relating to Alzheimer's disease and dementia, in brain chemistry may harm neurons, neurological connections, and other brain cells. Neurodegenerative diseases such as Alzheimer's have drastic impact on the lives of those affected by its conditions. In addition to symptoms that immensely alter patients' lifestyles, its implications extend to financial well-being of patients. To exemplify, changes in lifestyle and inability to work leads to a cost that is $4,000 USD greater than the expenses of a healthy individual [1]. In 2024 alone, health and long-term care costs for people

living with Alzheimer's and other dementias are projected to reach over $360 billion, which does *not* include the money spent for unpaid caregiving [2]. The total lifetime cost of care for a person living with dementia is estimated at ~$400,000, and out-of-pocket expenses in regards to dementia-related care is expected to total at $91 billion [2]. With the national average salary floating at $63,000 [3], these dementia-related treatment costs are *exuberant* for any patient and their family nationwide.

Scientists and medical professionals are hard at work, actively exploring treatments and medicines to slow Alzheimer's and dementia-related diseases' progression, manage symptoms, and slow its development through earlier intervention. Establishments should be made to strengthen programs that provide support to families, patients, and caregivers that are dealing with dementia-related diseases, including better funding, affordability for care options, and support groups and programs.

ABSTRACT

This paper explores current advancements in Alzheimer's disease (AD) care, treatment, and accessibility, and what improvements can be made on existing establishments of care and remedy. We examine present-day advances in optogenetics, retinal imaging, and biomarker research, as well as the implications of emerging drugs like Donanemab. Furthermore, it addresses the progressive and costly burden of Alzheimer's care, whilst also examining the underlying social and systemic challenges. Through a thorough discussion of these developments and advancements, our paper proposes strategies for improving access to care, amplifying early detection and intervention, and supporting policy reforms to alleviate the stress on patients and their families, as well as caregivers and healthcare systems.

DISCUSSION

Alzhimer's is a chronic disease which has seen a steady increase in recent years. Nearly seven million Americans are living with Alzheimer's, but by 2050, this number is expected to rise to nearly thirteen million [2]. Currently, Alzheimer's disease (AD) diagnosis is mainly based on clinical evaluations of cognitive and physical examinations, but in recent research, it has been found that pathological changes start occurring up to twenty years before symptoms start appearing. Alzheimer's disease (AD) typically stems from neurofibrillary tangles (NFT) or amyloid plaques, which result in loss of neurons and reduction in synapses, contributing to the pathology of this disease [2]. The accumulation of the amyloid beta (Aß) protein is linked to degeneration of neurons, leading to long-term neuronal damage. In a research article published by the National Library of Medicine, "Alzheimer's Disease and the ß-Amyloid Peptide" states that one of the hallmark pathologies required for diagnosis of Alzheimer's disease revolves around the extracellular plaque deposits of the Aß protein [4].

Current research indicates that amyloid plaques involved in Alzhiemer's disease progression result from an excess of Aβ peptide in the extracellular matrix of neurons in our central nervous system [4]. Proteolytic cleavage of amyloid precursor protein by certain enzymes leads to oligomers of Aβ to react to the cell surface of neurons that leads to an abnormality in the neuron's cell signaling pathways, which causes altered neuronal activities that cause dysfunctionalities in synaptic functions and plasticity [4].

Similarly, Tau proteins that are involved in phosphorylation cascades in neurons undergo hyperphosphorylation that leads to an abnormal accumulation of these proteins into pairs of helical filaments, causing NFT intracellularly [4]. While the issue of Aß protein accumulation has been extensively studied, understanding the role of the Tau protein in Alzheimer's disease presents more complexity. In its natural state, the Tau protein is stable and contributes to

regulating the cell, but when it is hyperphosphorylated, it is destabilized, leading to neuronal death. In 2009, the Tau protein was identified as a phosphoprotein, and research has suggested that hyperphosphorylation can be a treatment option. However, this approach is complicated, as through hyperphosphorylation of Tau, its function would change altogether. The hyperphosphorylation of specific sites on the Tau protein can disrupt its ability to stabilize microtubules and trigger overall pathological changes [6]. In fact, this process can lead to self-aggregation and toxicity, once again contributing to neuronal death and a diminishment in activity. Overall, looking at the current progress of Alzheimer's and looking for potential treatments, it is important to recognize the different molecular aspects of the disease and the myriad of ways they can be manipulated for treatment creation and curation.

Whilst understanding the underlying molecular mechanisms behind Alzheimer's disease is critical in development of effective treatments, the identification of biomarkers that provide for early detection and intervention of the disease is equally important to discuss. Deepening exploration of key biomarkers involved in the pathology of Alzheimer's disease can allow for much more advanced and accessible modes of treatment and monitoring for patients. When examining amyloid plaque build-up and aggregation of Tau proteins, a cerebrospinal fluid biomarker analysis, which is a test that involves a minimally invasive procedure that obtains fluid around the brain and spinal cord, is a frequently used test to diagnose Alzheimer' that has phenomenal potential for serving as a cost-effective method to test for Alzheimer's. A study that measured the cost effectiveness of cerebrospinal fluid biomarker examination to detect Alzheimer's found that this biomarker testing diminishes the occurrence of false-negative diagnoses and concluded that biomarket analysis is potentially cost-saving in high prevalence populations [5]. Not only does research in novel biomarkers of Alzheimer's pathology allow for

a higher likelihood of detecting the disease early for better treatment strategies, but it is actually one of the more cost-effective methods of diagnosis that is more accessible and affordable for patients.

Since Alzheimer's disease (AD) is a significant public health challenge, it is imperative that research is conducted to understand its onset and development. The use of biomarkers to identify Alzheimer’s disease is a crucial area of research that will allow for new developments and the advancement of our understanding of the disease. Biomarkers allow for individuals to assess and understand aspects of a biological process. As studies have shown, AD is associated with a loss of neurons and synapses in the cerebral cortex and specific subcortical regions. Retinal imaging technologies can improve risk assessment of AD, enhance screening techniques and provide insights into the development of treatments and preventative therapies [7]. Alzherimer’s is associated with alterations in the retina, which is a layer in the back of the eye that is sensitive to light. It provides an easier alternative to seeing how certain conditions impact the central nervous system (CNS). The measurements found through retinal imaging technologies enable the relationship between cognitive function impairment and the risk of AD to be examined. In addition to providing groundbreaking measurements, retinal imaging technologies are non-invasive and lower-cost. Computational techniques, such as AI, are also employed to further investigate the preclinical AD phase in individuals. However, some drawbacks include the need for specialized equipment and examinations of data by ophthalmologists or visual scientists. It is critical that AD is discovered in its beginning phases of onset to allow for treatments to be more effective.

Whilst advancements in diagnostic tools and imaging are crucial for early detection and intervention for Alzheimer's, exploring novel strategies for treatments provides significant promise in advancements in disease treatment and therapy. Optogenetics is a promising approach to a new wave of therapies for Alzheimer's disease (AD) which has the potential to increase accessibility and affordability of treatments [8]. AD is a critical neurodegenerative condition whose mechanism is primarily unknown. It significantly impacts neuronal circuits and brain plasticity — affecting memory and learning capability. Current treatments for AD patients include drug therapies (Tacrine, Donepezil, Carbalatine, Galantamine, and Memantine) that heighten cerebral performance and act as a booster for one's brain to maintain cognitive function. Optogenetics is a revolutionary therapy which can be used to stimulate neurons [8]. It works by delivering an opsin to the frontal lobe via a viral vector. The genetic material for the opsin is then replicated and the cell embeds opsins in the cell membrane to facilitate the diffusion of ions. Essentially, an opsin is a membrane protein that can be stimulated by certain wavelengths of light. Therefore, those wavelengths are targeted to the opsin from an external source, which can provide function in those degenerating neurons. Optogenetics is able to fight AD in a different way than the prior mentioned drugs. It actually does something to activate the dying neurons whereas the other drugs solely enhance other brain functions to compensate for the loss of function from AD. The new approach could become more accessible because it would be a viable solution to those who have built up a tolerance for the drug therapies. Some of the drug therapies also require around the clock care, which is not feasible. Optogenetics provides an option for a one time therapy to combat AD symptoms. A major limitation includes the large amount of clinical trials and testing before this idea can hit the market, There remains no guarantee that it would be a success. However, further research into specific light wavelengths

and how to deliver opsins more efficiently could greatly benefit the production of this treatment. Overall, the use of optogenetics makes AD treatments available to a wider audience for which traditional drug therapies are not viable.

In addition to optogenetics providing a promising frontier in Alzheimer's treatment, advancements in pharmaceutical medication provide critical opportunities for slowing the progression of Alzheimer's. Eli Lilly's Alzheimer's drug, Donanemab (also clinically referred to as Kisunla), recently received support from federal health advisors, who voted that the drug's ability to slow cognitive decline outweighed its risks [9]. The FDA's final approval decision is expected later this year, which could make it the second Alzheimer's drug in the U.S. to show measurable slowing of cognitive decline, following Eisai's Leqembi, approved last year. The drug was tested in a study of 1,700 patients, where it showed a 35% slowdown in cognitive decline through IV infusions [9]. However, there are concerns about safety, particularly regarding brain swelling and bleeding, which have been linked to amyloid-targeting drugs like Donanemab. Although most cases of these side effects were mild, three deaths in the study were associated with brain swelling or bleeding, with one linked to a stroke. Panelists agreed that these risks could be managed through monitoring, warning labels, and medical scans. While Donanemab offers promise in early-stage Alzheimer's treatment, concerns about its safety, particularly the brain complications, still need further investigation, and more data is needed on how to manage or stop treatment effectively to reduce risks and costs.

Alzheimer's disease is a well-known dementia, affecting millions of patients in America alone as one of the leading causes of death in the US. Alzheimer's can lead to issues with the memory, movement, and mood of patients [10], but one of the lesser-known and researched burdens of Alzheimer's is the cost burden. The estimated worldwide cost of dementia in 2015

was 818 billion US dollars and is expected to rise to 2 trillion US dollars by 2030 [10]. Much of this cost burden falls on patients and their families, who must juggle the cost and caregiving burden of Alzheimer's. Investment into research for Alzheimer's prevention and treatment can offset these costs. However, the issue runs deeper. Many innovative treatments for Alzheimer's disease have been developed; however, these treatments are costly and unavailable to the average patient and family affected by Alzheimer's. The average American family has an annual household income of about $52,000, less than the annual cost of many new Alzheimer's therapies [10]. Thus, there arises a need for an accurate way to measure the cost burden of Alzheimer's, to better understand and solve this cost crisis. Public policy must shift focus into developing Alzheimer's cost estimates that take into account not just the most visual costs of Alzheimer's but also the hidden ones, taking into account the cost of caregiving across generations [10]. The goal of policymakers and other relevant parties should be to understand how the cost burden of Alzheimer's changes as the disease progresses, from its earliest stages to the most severe. This assessment can help us identify where our current efforts to support patients and families are failing, allowing for targeted and effective research into Alzheimer's prevention, treatment, and care.

While addressing the financial burden patients and their families experience, enhancing the quality of care through improved assisted living and care options offers another avenue for alleviating and overcoming potential challenges. Improvements in assisted living and memory care units can possibly improve the lives of patients with Alzheimer's disease and related dementias, or ADRD. Enforcing policies and regulations for better-trained staff for non-pharmacological treatments, increasing consumer education, and allowing for resident-autonomy can create a greater quality of life. Assisted living facilities provide at least

two meals a day, 24/7 supervision, and help with personal care. Though assisted living facilities are not licensed as nursing homes, preventing facilities from addressing complex care needs. Despite their limitations, assisted living facilities require stable and "particularly competent" staff to care for patient's medical and psychological needs [11]. In fact, assisted living communities are and remain the primary providers for older adults with ADRD like dementia [12]. As of 2018, 25% of assisted living facilities exclusively serve people with ADRD, or a unit, wing, or floor dedicated to people with ADRD [11]. Another estimate from national data indicated that 70% of residents in assisted living communities have some form of cognitive impairment, with 19% of patients classified with severe impairment [12]. A sample from 50 staff reporting on 166 residents 14 assisted living communities concluded that 90% of screened patients had dementia [13]. Much like nursing homes, assisted living communities have been facing a severe shortage of competent and reliable staff, with only about a 66% of staff retention in assisted living according to a 2017 California statewide study [12]. Though there is an imperative for better trained staff to support the required 24-hour care in assisted living communities, models pushing for greater resident-independence have enabled more individualization and innovation in communities. Both larger and smaller communities have been associated with greater resident autonomy and satisfaction, while residents in larger communities have reported feeling more at home than those in smaller communities [14]. Though there is a need for residents to achieve greater autonomy and possible independence, there is a need for better-trained staff to handle medication administration, better care for patients with ADRD, and promotion of consumer education.

Branching off into the discussion of access to care, digital teleconsultations have vast potential to lower healthcare costs and enhance accessibility to neurological care. Telehealth is

both feasible and beneficial for healthcare providers to reach patients with longitudinal follow-ups; Sadeghi et al. achieved a rate of 87% successfully completed telehealth consultations over a follow-up period of twelve months [15]. Telehealth consultations have the potential to reduce overall government spending on healthcare in the United States as well. A research article about telehealth explained how telehealth can reduce healthcare spending by decreasing problems like medication misuse, unnecessary emergency department visits, and prolonged hospitalizations [15]. Economically speaking, telehealth has the potential to stimulate competition amongst providers as providers can practice interstate, which would drive down costs charged by providers.

Alzheimer's disease imposes challenges that range far beyond medical as patients and their families struggle with the strain of costly healthcare, inadequate living facilities, and the search for care. Beyond its physical symptoms, Alzheimer's disease becomes a heavy mental burden. It is estimated that roughly 50% of patients develop depression as a symptom of AD, and this is often debilitating [16]. This psychiatric disturbance further complicates care and diminishes overall quality of life for both patients and their caregivers by significantly worsening the cognitive decline associated with AD. In fact, studies have indicated that as many as 90% of patients with Alzheimer's can have some form of psychiatric disturbance, major depression afflicting about 24% [16]. This emotional toll can cascade further into increased apathy and social withdrawal, and a decline in physical health contributes to shaping the course of the disease. This bidirectional interaction between depression and cognitive impairment complicates diagnosis and treatment because symptoms may overlap or mask one another. Although existing evidence points to the fact that antidepressants can perform significant improvements in depressive symptoms for 50% to 75% of patients, there are a multitude of individuals who still

remain untreated or inadequately managed due to limited research and a lack of comprehensive treatment strategies [16]. This underlines the need for further studies that would consider effective therapeutic options, at least in general, and social and cultural factors affecting the recognition of depression in patients with Alzheimer's, as well as the application of treatments. After all, addressing these aspects is vital to better mental health outcomes for sufferers of this devastating disease.

Additionally depression is part of both a prodromal symptom and a risk factor for Alzheimer's disease. They comment on how depression usually precedes AD diagnosis and support a common biological cause: the neuroinflammation-neurodegeneration-neurotransmission axis [17]. These coincidences may provide arguments for overlapping mechanisms between mood disorders and neurodegenerative processes, emphasizing the importance of early intervention in depressive disorders. According to the authors, it is important that depression be effectively treated in older adults, as this may be a way to delay the onset of AD or slow its development-a fact that might provide relevant information for developing therapeutic strategies that address psychiatric and neurodegenerative pathology. This review underlines the comprehensive need for longitudinal studies and a multi-disciplinary approach in managing depression that might help substantially in AD prevention strategies and improvement of outcomes.

CONCLUSION

In order to approach the issue of increasing accessibility of care for affected patients, it is crucial to highlight and focus on certain elements of Alzheimer’s. There are three primary areas of focus: understanding the pathophysiology of the disease, plan to deliver care and prevention strategies that are of high quality and of lowered cost, and the prominence of telehealth. Proper

comprehension of the pathophysiology of Alzheimer's allows for analyzing the most cost-effective and optimal prevention or treatment strategy for patients. Notably, understanding the biomarkers that indicate pathogenesis of Alzheimer's allow for early detection, better tracking of disease progression, and enhanced treatment response monitoring. Finally, addressing the financial, emotional, and logistical burdens of care–including the obstacles of finding high-quality, affordable assisted living facilities and care options–can enhance the quality of life not only for patients, but for their families and the healthcare professionals that work alongside them.

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