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IoT-enabled solutions for Alzheimer's disease management: innovations and opportunities

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ABSTRACT: Alzheimer's disease (AD) is a common neurological disorder characterised by the progressive shrinkage of brain tissue and the death of cells. Understanding how genetic and environmental factors interact to cause AD is challenging but crucial for effectively managing and treating this disease. Many personal, social, and economic impacts can be attributed to AD, making it a crucial area for research. This paper proposes using Internet of Things (IoT) technologies to assist people with Alzheimer's disease. IoT can potentially enhance people's quality of life and simplify daily activities. IoT applications in healthcare, smart homes, and patient tracking have been explored. Various sensors, devices, and software can be utilised to monitor patients' health status. By leveraging IoT, we can develop innovative solutions to address AD management challenges and improve the overall quality of patient care.

Keywords: Alzheimer's; Dementia; Internet of Things (IoT); Neurologic; Sensors

1.0 INTRODUCTION

The world's population is increasingly ageing, with the number of people over 60 estimated to be 702.9 million in 2019 and 1548.9 million in 2050, showing growth in instances. According to a 2019 survey, stroke (37.9%), headache disorders (17.5%), and other neurological conditions were India's leading causes of neurological diseases (Masters et al., 2015). The brain is one of the body's essential organs most impacted by today's innovations. The human brain is the most complex organ (Hummadi & Chatterjee, 2021). One in six people worldwide suffer from brain disease, ranging from multiple sclerosis and epilepsy to traumatic brain damage, Alzheimer's, and more. Although there is no medicine for Alzheimer's disease (AD), an alternative cure can help manage the warning signs of this disease more slowly. The illness cannot be halted once it has taken hold. The only option available now is to stop the progression of the illness to improve patients' quality of life.

Most typically, Alzheimer's disease is distinguished by

disorientation, impairment of memory, and disorientation, difficulty thinking clearly, and other symptoms. Alzheimer's disease is a catastrophic neuro-degenerative brain illness that occurs when many brain cells die. It is challenging to acquire symptoms once a person has been diagnosed with this disorder. The loss of neurons in the brain affects its ability to communicate with other bodily parts. The World Health Organisation claims that around 40 million people worldwide might be affected by Alzheimer's disease, which frequently causes severe social issues and financial costs (WHO, 2023). The worst-case scenario of Alzheimer's (AD) is death. Since Alzheimer's disease is one of the most significant health challenges, millions worldwide are affected.

We know that a vitamin shortage in the body has several negative repercussions. Vitamin insufficiency can result in several issues, including slow physical growth, bad eyesight, and even mental disorders (Bansal & Chatterjee, 2022). Various alternatives or safeguards must be taken to avoid this worst-case situation. We identified three key patterns that can predict the early indications of Alzheimer's in older adults based on recent Alzheimer's studies (Zhang et al., 2020). Our approach is based on data from IoT devices (Zhang et al., 2020), which includes sensors, health bands, remote patient monitoring (measures blood pressure and temperature), mood-aware IoT devices, smartwatches, and smart home appliances GPS for tracking the movement of patients, which helps patients to live with ease.

The term "Internet of Things" (IoT) describes electronic gadgets linked to the Internet that can gather and send data over a wireless connection. In the contemporary era, data can be shared between gadgets linked to the internet without human intervention. A home video camera can be useful for caregivers as well. The video camera in the house raises ethical questions, but people with dementia and those who care for them find it very useful. There is no concern about losing a patient's movement thanks to the availability of various GPS tracking devices. Patients with Alzheimer's will not recall how to get home, so wandering could be risky, and care must be taken. This manuscript combined various risk factors and how we use IoT technology with sensors for those patients.

Figure 1 illustrates the annual prevalence of dementia/AD, including projected estimates in millions up until 2030-2050. This graphical analysis emphasises the necessity of the manuscript, aiming to raise awareness regarding the profound impact of this disease on individuals and their families. The document outlines preventive measures that can be adopted by family members or caregivers while also introducing a range of IoT-enabled tools designed to monitor patients' daily activities.

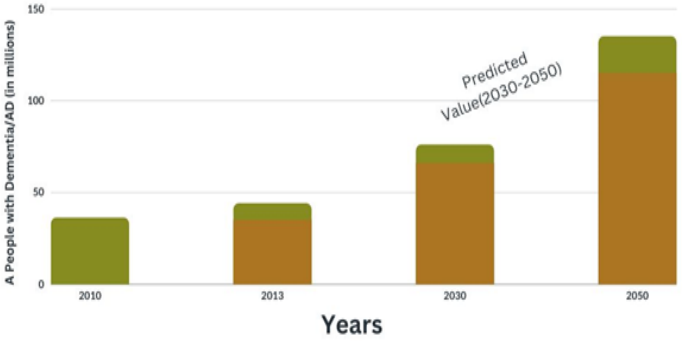

Figure 1: Cases of dementia/AD in 2010 and 2013, projected to 2030-2050. The chart was prepared based on the data source (https://www.alzint.org).

2.0 SOCIETAL IMPACTS ON ALZHEIMER'S PATIENTS

Alzheimer's disease (AD) is characterised by a gradual loss of intellectual capacity, including issues with spatial perception and short-term retention of information (Salehi et al., 2022). Patients with AD/dementia deal with various issues, such as sleep disturbances, the inability to carry out everyday tasks effectively, medicines self-discipline, irritability, forgetfulness, social alienation, and depression.

A total of 15.3 billion hours of care were provided to AD patients in 2020 (Haro et al., 2014). Caring for another person's health and well-being is called caregiving (Sheikhtaheri & Sabermahani, 2022). Caregiving can be emotionally and physically taxing, leading to caregiver burnout and decreasing both the health of the patient and the caretaker's standard of life. IoT-based technology can provide much-needed relief to caregivers and improve the quality of life of patients with AD/dementia. Some benefits of using IoT technology for AD/dementia patients include remote patient monitoring, tracking of medication adherence, and improving patient safety through sensors and smart home devices. IoT devices can also assist with daily tasks such as reminding patients to take their medications and helping with meal preparation.

In addition to the benefits for patients and caregivers, IoT technology can positively impact society. By

reducing the burden on healthcare systems and allowing patients to remain at home longer, IoT-based solutions can help address the societal impact of AD/dementia. However, there are also challenges connected to the usage of IoT technology in the healthcare field, including data privacy and security issues and the need for adequate training and support for caregivers and patients. Overall, IoT technology shows great promise in improving the lives of AD/dementia patients and their caregivers (Sheikhtaheri & Sabermahani, 2022). As the world's population ages, we must continue to explore and develop innovative solutions to address the growing burden of this devastating disease (Velilla et al., 2022). Remorse, regret, sadness, and fury are common feelings caregivers and families experience.

2.1 Guilt

It is pretty typical to feel guilty about anything, whether it is remorse over how the dementia patient was mistreated in the past, shame at their odd behaviour, regret for losing your temper, or regret over not wishing to take on the work as a caregiver for a dementia patient. Even if you have done all necessary to keep the Alzheimer's patient at home for as long as possible, you may be disappointed when they are in a hospital or long-term nursing facility. When past commitments such as "I will always look after you" are broken, it is normal to feel guilty.

2.2 Grief and Loss

Loss produces a feeling of grief. We lose the relationship and the friend or relative we previously knew when they get AD and the shared future they had planned for. Because grief is a deeply personal emotion, different people will feel it differently at other times. Time will pass, but it will not always get any better.

2.3 Anger

It is common to feel frustrated and angry for several reasons, including needing care, others who do not want to help, the dementia patient's challenging behaviours and support services. There may even be times when you want to shake, push, or even hit the person living with dementia. Distress, frustration, guilt, fatigue, and annoyance are legitimate emotions. However, if you experience this or fear that you may lose control, it is essential to talk to someone about your feelings, such as a physician or someone from the Alzheimer Society.

3.0 PSYCHOLOGICAL IMPACTS

It is generally accepted that more severe neuropsychiatric symptoms (NPS), such as sadness, apathy, violence, and psychosis, are signs of a quicker loss of cognitive function, freedom and even lower life expectancy. NPS is increasingly seen as a crucial sign of Alzheimer's disease (AD). It is unclear if these signs have distinct aetiologies associated with AD-associated neuropathy or whether they are brought on by the same pathogenic pathways that cause cognitive loss. Specific structural and a range of neuropsychiatric symptoms or symptom clusters are connected with metabolic characteristics of the AD brain. In other instances, many genes have also been connected to symptom risk. No specific genes strongly predict distinct neuropsychiatric disorders, although functional and structural alterations in the brain associated with particular symptoms may reflect variance in similar illness mechanisms (Chatterjee & Chatterjee, 2023). The pathobiology and management of these psychiatric symptoms require further study because, regrettably, they may be less effectively treated when AD is present. This review presents two of the key components of NPS pathogenesis: i) depression and ii) agitation and aggression.

The symptoms of this stage can include the following: i) disorientation and memory loss; ii) reduced ability to focus; iii) recognition issues; iv) difficulty organising thoughts and using reasoning; v) difficulty with reading, writing, and dealing with numbers.

4.0 NEUROLOGICAL IMPACTS

Alzheimer's disease (AD) is the most typical form of dementia and severely negatively affects society, the economy, and people's lives. The early 1900s saw the first neuropathological descriptions of AD. Today, we can detect and diagnose individuals' AD and underlying AD diseases.

Nosology is the study of the identification or taxonomy of diseases. The fundamental contributions made by Dr. Oskar Fischer and Dr. Alois Alzheimer continue to serve as the foundation for the current understanding of the disease (AD). Both researchers described how AD's core pathology progresses from affecting many higher-order cognitive functions to typically manifesting as short-term semantic memory issues. The advancement of the disease may be accompanied by other cerebral and behavioural abnormalities, which are frequent but varied aspects. These characteristics

include but are not limited to nervousness, aggressive behaviour, intoxication psychosis, boredom, dissatisfaction, sadness, anxiety, difficulties in sleeping, and disordered eating. With Alzheimer's disease, the average lifespan is seven years, but some people advance more quickly than others (Larson et al., 2004).

Ultimately, AD patients die from its complications, frequently connected to infections like pneumonia. AD exacts a substantial personal, societal, and economic toll due to its slow progression and prevalence. Without effective interventions, this toll will significantly rise in the ensuing decades. Logical characteristics of the post-mortem AD brain include plaques, neurofibrillary tangles, and neuronal loss. Before death, progressive deterioration of other higher-order cognitive abilities and dementia were observed in individuals who underwent examination of the brain and hippocampus, revealing these alterations (Chong et al., 2017). AD could also be called plaque and tangle dementia, often known as Fischer's illness. Still, as other experts have elegantly explained, political pressure and squabbling among scientists led to the name AD being chosen for this particular form of dementia (Golde, 2022).

5.0 IoT FOR MAKING PATIENTS' LIVES EASY

This article aimed to determine how people with Alzheimer's may use the IoT and the technologies used worldwide for the patients. Many technologies are used for AD/dementia patients, including radio frequency identification (RFID), Bluetooth, global positioning systems (GPS), sensors, and cameras, most of which are sensors to track switches and significant signs are used to facilitate healthcare tasks (Sheikhtaheri & Sabermahani, 2022). Several wireless ICT (information and communication technologies) devices, including those that monitor blood pressure or blood glucose levels, scales with sensors that record weight fluctuation, and portable ECG monitors that identify cardiac pulse problems, are used to enhance healthcare tasks (Oudshoorn, 2012).

As AD patients cannot recognise things, and the most common risk is that they will not be able to find their way home once lost, several technologies can be used to prevent the worst situation. This technology analyses the surroundings using sensors or controllers. Most of them have connectivity via communication tools such as internet access and the GPS for mobile to communicate with control centres, relay environmental data, and support decision-making. People are currently creating smart houses all around the world. Our lives frequently involve online interaction, including emailing people worldwide, blogging, social networking, and participating in online events such as CME classes, among other activities. Neurologists may now access neglected rural areas to deliver care remotely, thanks to technology, which can help improve patient safety and care (Mohamed et al., 2022).

IoT technology is mainly implemented by incorporating sensors into various objects that can connect using communication technology. Many study papers and literature works reveal that the Internet of Things connects all those objects with sensors to help and make life simpler for individuals with various conditions. With changing demographics, proper healthcare is essential, which can increase patient costs; therefore, the need for affordable solutions is undeniable (Majedi et al., 2016).

This technology is used in the healthcare industry, among other things, to monitor objects, people, and patients, to identify and authenticate people, and to gather patient health data continuously. Physicians and staff use patient status monitoring systems to control heart rate, breathing pace, and blood pressure. The Internet of Things can be used in healthcare for verification and recognition, such as specific patient identity to prevent abrupt and hazardous events, electronic medical records, and hospital identification. The sensors can focus on patients, detect their state, and send patients and their companions real-time data to improve their health markers. Other applications include telehealth, observing patient medication adherence based on their current conditions, and alerting patients when critical health status and vital signs are present.

The Internet of Things (IoT) is an important concept to remember. In the medical field, various communication technologies like wireless internet, RFID, radio frequency WSN, NFC, and Bluetooth facilitate communication among different entities. To remotely monitor a patient's critical functions (such as keeping track of glucose, temperature control, arterial pressure, respiration rate, levels of cholesterol, and glucose monitoring), sensors transmit data to physicians or physicians.

Internet of Things technologies such as sensors, gadgets, mobile devices, applications, pervasive smart home systems, and other components can all be included in remote monitoring technologies. These

technologies are utilised in health equipment and informatics. Mobile phones may assist in analysing social behaviour by analysing calls, text messages, or web surfing, and as older phone usage rises (Perrin & Anderson, 2019), so are smartphone health applications. Moreover, wearable smart gadgets and remote health management solutions have grown in popularity over the last ten years, particularly among older people and persons with dementia.

Smart home healthcare solutions, in particular, can dramatically postpone rest home admission and encourage safety surveillance and care of older persons via smartphones, smartwatches, and other sensors. In the retail electronics industry, trackers and bracelets are thriving (Salehi et al., 2022). IoT offers reliability in the field of healthcare as medical issues are increasing day by day (Oskouei et al., 2020).

Numerous elements, including a family, medical professionals/emergency, and a web server, are connected by Wi-Fi in the condition depicted in **Figure 2**. This illustration shows how IoT-enabled sensor devices that monitor a patient's rhythm, elevated blood pressure, saturation level of oxygen, and mobility operate to preserve patient health data. The patient database, which contains details on the patient's health status and mobility, is generated using all the sensor data collected and saved on a cloud server. A warning must be sent to family and medical professionals in an emergency. As a result, they can provide patients with assistance as soon as possible. IoT devices greatly assist carers in providing patient care, including monitoring their health and tracking their whereabouts.

5.1 Image pre-processing

The processing of medical images' effectiveness algorithms is influenced by non-linearity in light intensity. A faulty lens aperture setting on medical imaging systems mainly causes it. Following that, the photos are pre-processed utilising image-enhancing tools. Contrast stretching, which normalises the image's intensity range, is a fundamental approach for image enhancement. The image's dynamic range can be increased using various techniques. However, linear stretching is a reliable and effective method (Khan et al., 2019).

5.2 GPS and mobile tracking

It suggested and put into practice techniques for locating and monitoring Alzheimer's patients, giving a fresh approach to cases of wandering and becoming lost. The system was created using already available technology to create a little tracking device connected to the internet. IoT-enabled devices are helpful for caregivers or patient's families. **Figure 3** includes the IoT devices which are discussed in this manuscript. The tracking device's internet connection makes quick access to location data possible. Therefore, carers or patients' family members can readily access a map that illustrates the precise place of the patient through the developed web mobile applications (Zhang et al., 2020).

5.3 Clothes sensors and RFID (Radio Frequency Identification)

It is also crucial to emphasise that patients only need to carry the device; no human interaction is required to transmit location information to the server. It would be simpler to attach the gadget to clothing or footwear because of its small size. Short-range communication uses radio-frequency identification (RFID) (10cm – 200m). It consists of a tag and a reader. These tags were produced using a microchip and an antenna. It specifically identifies an object or device in the IoT context (such as medical equipment). These readers use radio waves to exchange information with a tag attached to anything. An electronic product code serves as the information used in the tag. RFID's primary benefit is that it does not require an external power source. It is, however, a very unreliable method that could have compatibility concerns when connecting to a smartphone (Chacko & Hayajneh, 2018).

5.4 Alzheimer detection

RFID integrated an active portable wristband for radio frequency identification with Infrared room locators to track the location of older adults at the room level (Chong et al., 2017). Novel digital technologies can dramatically increase the potential of many diagnostic and treatment instruments and systems (Chevrollier & Golmie, 2005). For example, medical professionals can gather patient data and conduct electronic conversations using readers that read RFID and Near Field Communication (NFC) devices. These devices are the primary source of massive data sets since they may continuously create data while examining a person's health (Senbekov et al., 2020).

5.5 Wearable devices

Wearable technology allows observing medical data and behaviour details, including exercise phases, activity types, and social contacts. The development of wearable technologies can combine data from multiple

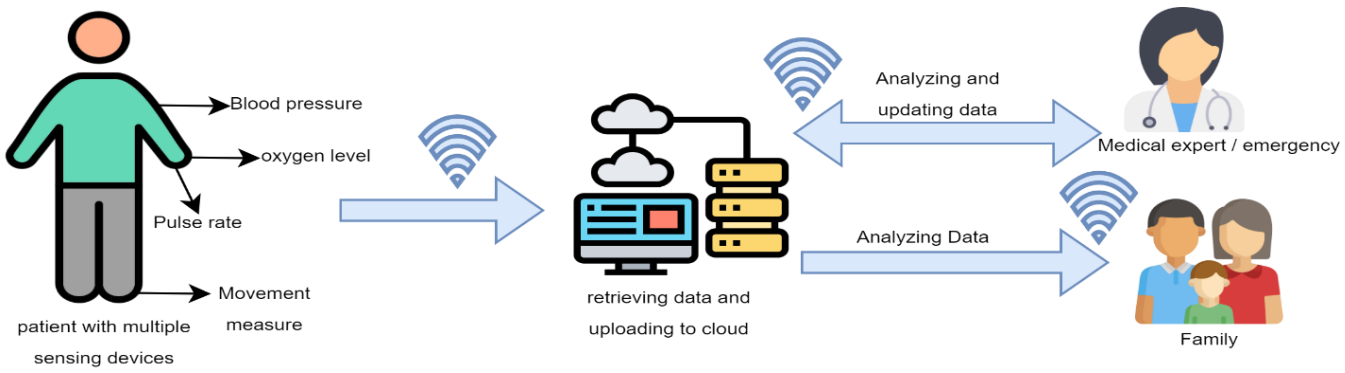

Figure 2: Working of IoT devices in AD Management.

sources to provide additional information. There are new chances for care providers due to many factors and activities, such as behaviour-related, emotional, and therapeutic, but integrating care models is also necessary (Lewy, 2015). Wearable devices help doctors and patients to deal with various health issues at a minimal cost. These devices are handy for keeping track of health factors, and they may be combined with various sensors with human wearables like watches and wristbands (Chacko & Hayajneh, 2018). Smartwatches are becoming an essential digital instrument for gathering Alzheimer's disease-specific endpoints and biomarkers (Stavropoulos et al., 2021).

5.6 Smart home appliances

A home that employs a Home Controller to merge all its house management devices is called a "smart home." The most common personal controllers can only be configured when coupled with a Windows machine and left to their own devices. The capacity to control several house systems at once by integrating the home systems, pre-programmed events or operating modes can be triggered with a single click or voice assistant to enable communication via the host controller (Robles & Kim, 2010). Smart home technology greatly aids caregivers in effectively managing patients. A caregiver can control doors, windows, lamps and lights by voice control.

6.0 SMART HOME APPLIANCES FOR PHYSICALLY CHALLENGED INDIVIDUALS

Unwell individuals who face mobility challenges often depend on caregivers or family members for constant assistance. Smart home appliances, such as an effective security system, can provide a solution, especially for those who live alone and do not always have anyone around them. A smart home security system lets homeowners see visitors on camera and communicate with them through microphones and speakers. In cases where the individual with an illness cannot move, the security system installed at home can unlock and open the door to allow the visitor to enter. The smart home system can also recognise authorised visitors and their level of access to various parts of the house (Robles & Kim, 2010).

The caregiver uses the smartphone with (IoT) platform application: 1. Check on the patient to see if he is stable; 2. Receives alerts if anything happens; 3. Set reminders for various patient activities; 4. A notification is generated if the patient leaves the connection zone, 5. Track the patient and display his location on the tracking application; 6. Keep monitoring the heart rate.

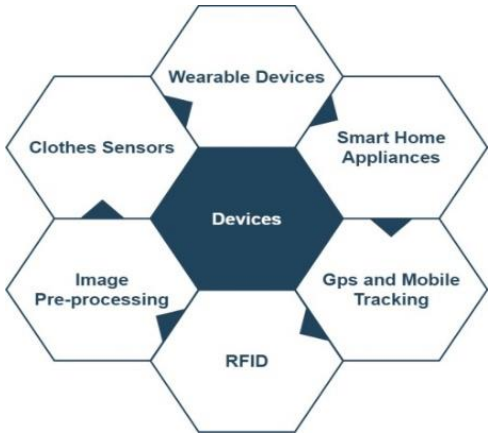

Figure 3: Compilation of IoT devices applied for Alzheimer's disease.

7.0 CASE STUDIES OF ALZHEIMER'S PATIENTS

Smart houses with IoT capabilities aim to create an atmosphere to live with assistance, making regular, unobtrusive monitoring of elderly persons possible. The surveillance technique of events gathers

sequences of acts or occurrences used to determine the rhythmical repetition of activities or events associated with wandering behaviour. Areas could be equipped with sensors to track motion and vital indicators. For instance, the sensor could identify a roaming pattern if the patient is disoriented and wandering. Conversely, a sudden decrease in activity could indicate a patient's apathy, who may become more reclusive and isolated. The sensors attached to appliances like gas, taps and data from medicine cabinets help assess how appliances are used in addition to movement and location analysis. The analysis can help identify older people's forgetting behaviours (Chong et al., 2017).

Alzheimer detection via the IoTs: Chong and colleagues employed an active wearable RFID bracelet to track the whereabouts of elderly individuals at the room level, using infrared room locators. IoT technology is being proposed to study patient behaviours for early dementia identification. Their study's primary determinant is based on forgetting, and sensors for fuel, water sources, electricity and shutting doors record this information. Only two cases were assessed, and comparisons are primarily found in the results. However, the main factors in their study include repetitive behaviour, excessive levels of activity, and sleeping difficulties. They also tested their strategy on 20 older people living alone in housing developments with front door and room sensors. In the next section, we describe the data they collected and the IoT sensors' characteristics (Chong et al., 2017).

By our comprehensive data analysis, the variable "Abnormal sleeping patterns" exhibits a degree of bias attributed to visitor influence, inaccurate sensor readings, and instances of missing data. This bias, as documented by Chong and colleagues in 2017, results in the frequent and exaggerated calculation of duration (Chong et al., 2017).

8.0 SENSORS USED TO DETECT ALZHEIMER'S

8.1 Immuno-Infrared Sensors

A sensor can detect indicators for misfolded proteins in the blood, which could help identify Alzheimer's disease before symptoms appear. Researchers are trying to develop it for the market. There is a 15–20 years symptom-free interval with Alzheimer's disease before any medical signs appear. A study team has detected indicators of Alzheimer's disease in the blood using an immuno-infrared sensor created in Bochum up to 17 years before the onset of the first clinical symptoms (Budde et al., 2019). The sensor can detect the biomarker protein amyloid –β [Aβ] misfolded, which results in distinctive deposits in the brain, known as plaques, as the disease worsens. Immuno-infrared sensors aim to detect those plaques early before the situation becomes uncontrollable. We can detect the toxic plaques formed in the brain through a simple blood test (Budde et al., 2019).

8.2 Optical Sensor Array

The traditional methods for detecting tau proteins and A peptides, which are AD biomarkers, primarily rely on neuroimaging and immunological testing. **Table 1** includes the following sensors, which might be helpful for the detection of Alzheimer's disease. Low-sensitivity immunosorbent tests and positron emission tomography imaging are expensive and radiation-intensive, limiting their practical applications. Optically based sensors can detect biological analytes without invading and offer excellent sensitivity and simplicity. Significant research has been done on colourimetric alterations to diagnose AD biomarkers.

Recently, optical sensors have been developed for the diagnosis of AD biomarkers. **Figure 4** explains the process of diagnosis. Fluorescent sensors exhibit significant signal changes when exposed to specific analytes and are frequently used as effective tools for monitoring biomarkers in vitro and in vivo. A standard optical biosensor consists of an optical transducer system and a bio-recognition sensing device, which generates a signal corresponding to analyte concentrations. A wide range of optical biosensors, such as to measure the quantity of AD biomarkers (Aβ and Tau) for the early diagnosis of AD, colourimetric biological sensors, luminous biosensors, surface-enhanced Raman scattering (SERS) detectors, localised surface plasmon resonance (LSPR) detectors, and others have been developed. Fluorescence-based Nano biosensors have recently been developed and are beneficial in the sector of optical sensors because they offer high-sensitivity fluorescence detection (Phan et al., 2021).

9.0 LIMITATIONS ASSOCIATED WITH IoT TECHNOLOGIES IN THE CONTEXT OF AD MANAGEMENT

9.1 Security

IoT security is a serious problem since hackers or assailants can stealthily obtain data from devices. It might be possible that some unauthorised person can access the patient's history and data, which might be dangerous for patient security. Knowing the many current IoT security strategies is essential.

Table 1: Lists of sensors for Alzheimer's detection.

Name	Sensors	Service offered
Immuno-infrared sensors	ATR crystal	For the preclinical detection of Alzheimer's disease (AD) in bodily fluids, an immuno-infrared biosensor was created.
Optical biosensors	CMOS cameras Linear array, Optical switches	Optically based sensors based on fluorescent or considerable research have been done on colourimetric alterations for the biological analytes that can be detected. Recently, these have been used to detect AD.

To protect privacy, IDP (IoT-dependent data placement) is one such method. According to data security constraints, this suggested technique's primary goal is to maximise data access by utilising resources efficiently and consuming electricity as little as possible. NSGA-ii (non-dominated sorting genetic algorithm) algorithms can reduce power consumption while maintaining privacy. A cloud service handled the approval work while this approach was locally assessed using data on current health conditions derived from patient health evaluations. Radio-frequency recognition is based on an encryption strategy used to secure medical data. In a network setting, the flow of data for health information is highly complex, and data security in wearable health tracking systems depends on biometric security with resource constraints (Upadhyay et al., 2023).

9.2 Limited battery life

Small batteries are found in most IoT devices. The fundamental reason is that the devices are frequently incredibly tiny, and new IoT technology generations favour smaller, more efficient devices and parts. Larger batteries may limit a device's use or the locations and installation options available. The patient's wearable devices might run out of battery at some crucial time. For instance, installing a larger battery on a predictive maintenance sensor would restrict you from placing it where it most protects from damaging elements like high temperatures, debris, impact, and other situations.

9.3 Coverage

A network connection is required for IoT devices to send and receive data. If the connection is lost, the device's functionality is also lost. Although several IoT connectivity options exist, each is better suited for a particular coverage. Your deployment options may be significantly constrained by the solution you select. As a result, coverage is an ongoing IoT concern. For IoT connectivity, Wi-Fi is a typical option. However, you can only use your gadgets where there is Wi-Fi, and they can only operate within a short distance of a router. To ensure operational continuity, you have two options: invest in developing the necessary infrastructure if not already in place or equip your devices with a pre-existing backup solution that offers reliable coverage.

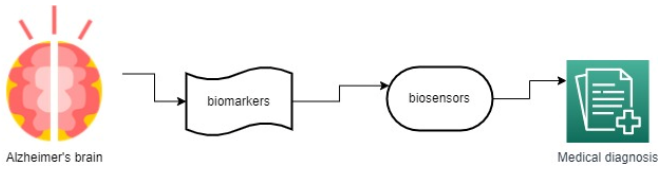

Figure 4: Utilising biosensor technology for detecting the presence of Alzheimer's disease (AD).

9.4 Challenges associated with IoT technologies

The first challenge is that external noise impacts the performance of data transmitted from sensors to controls and then forwarded to checkpoints. Data can be sent using enhanced architecture without disrupting the original pattern. A noise-supporting strategy might be used to maximise the data signal's intensity.

Second, due to their extensive usage and the increased energy requirements of the associated devices, there is an increased risk of energy acquisition and power leakage as the amount of sensors increases. As a result, an optimised approach is needed to reduce energy use.

The third difficulty is providing in- and outpatient monitoring with the facilities and resources connected to various hospitals (Jorge-Lévano et al., 2021).

The fourth challenge is that more e-healthcare facilities should be available to ensure everyone can access adequate healthcare.

10.0 CONCLUSIONS

Alzheimer's disease is a common illness that affects people as they age. Despite an increase in its occurrence worldwide during the past decade, the cause remains unclear. While it has been widely hypothesised that mental stress or genetic inheritance may be contributing factors, there is no definitive

explanation. Although doctors and researchers have recommended pharmacological and non-pharmacological treatments to help people with Alzheimer's disease, none of them have proven to be completely effective. Providing care for AD sufferers requires constant attention from family members or caregivers.

The Internet of Things (IoT) has become increasingly popular worldwide in recent years. Consistent indoor and outdoor monitoring can prove advantageous for individuals living with Alzheimer's disease. IoT devices such as wearable watches and GPS tracking are available to track the patient's movements. Various sensors, including MRI and immuno-infrared sensors, are used for the early diagnosis of Alzheimer's disease. Neuroimaging techniques have the potential to expedite diagnosis, help identify those who are most prone to acquire the disorder and provide a scientific basis for the development of novel pharmaceutical treatments. To facilitate future advancements, the development of all-in-one sensors or skin patch sensors is recommended. Such technology would eliminate the need for Alzheimer's patients to utilise multiple sensors for monitoring their health, thereby significantly assisting caregivers in their responsibilities. It is crucial to establish additional health centres equipped with adequate facilities to expedite the diagnosis of this disease, given the escalating incidence of the condition.

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Conflicts of Interest: The authors declare no conflict of interest.

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