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Assessment of Cognitive Assistive Technologies in Elderly Patients with Dementia Post-COVID-19 Infection: A Research Proposal

Aleena Sajid, BMSc Student [1]*, Mehak Behal, BMSc Student [1], Aashna Agarwal, BHSc Student [2], Jainee Patel, BMSc Student [1], Vidhi Bhatt, BSc Student [3]

[1] Department of Medical Sciences, Western University, London, Ontario, Canada, N6A 3K7
[2] Department of Health Sciences, McMaster University, Hamilton, Ontario, Canada, L8S 4L8
[3] Department of Integrated Sciences, McMaster University, Hamilton, Ontario, Canada L8S 4L8

*Corresponding Author: asajid3@uwo.ca

Abstract

Introduction: SARS-CoV-2 infection is thought to be implicated in an increased risk for various neurodegenerative diseases given its role in neuroinflammation. As a result, cognitive assistive technologies to monitor the risk of neurodegenerative diseases in those with prior COVID-19 infection and the regular implementation of practices designed to promote synaptic plasticity may decrease the risk of dementia in susceptible populations. It is hypothesized that incorporating frequent use of a mobile application designed to improve memory five times per week in the daily routines of patients aged 65+ who have survived a COVID-19 infection may decrease the prevalence of subsequent dementia.

Methods: The goal of this application would be to (i) deliver interventions related to long-term potentiation, and (ii) centralizing patient health data in a singular domain to improve ease of access for caregivers and medical staff. This may be investigated through a two-pronged randomized controlled trial aimed to compare neural and cognitive functioning through repeat neuropsychological exams, magnetic resonance imaging, and electroencephalogram tests over a 6-year timeframe between no-intervention and intervention groups while collecting caregiver and healthcare worker data regarding its efficacy in improving quality of life.

Results: It is expected that patients consistently using cognitive assistive technologies in long-term care facilities will experience lower incidence of cognitive decline compared to the control group due to improved maintenance of mental health and the learning of new skills. In addition, with the use of technology, patients may experience increased autonomy and independence, improving their quality of life while simultaneously providing relief to their families and caregivers.

Discussion: Some further considerations may include the degree of technological proficiency of the patients during the development process to ensure that patients reap the maximum benefits.

Factors including rapid development and testing, funding, and strong technology support systems must be taken into consideration to ensure a seamless transition to increased reliance on technology in post-COVID-19 patients with dementia.

Conclusion: Strong evidence indicates technology-based interventions can be used to by dementia patients and their caretakers overcome physical and environmental challenges normally and during future pandemic waves.

Keywords: cognitive assistive technologies; COVID-19; dementia; neurogenerative diseases; gerontechnology; cognitive decline

Introduction

Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), otherwise identified as COVID-19, is commonly known as a contagious respiratory disease. Growing evidence associates the virus infection with neurological and psychiatric after-effects. Many individuals with past illness from COVID-19 report symptoms including brain fog, anxiety, mood changes, and difficulty in memory and concentration. COVID-19 has the ability to affect brain function via chronic hypoxia, metabolic and immune dysfunction and systemic inflammation [1]. Recent literature also suggests that the virus has the potential to cross the physiological and anatomical barriers shielding the brain, notably the blood-brain barrier (BBB) [2]. BBB works to prevent harmful substances including pathogens from central nervous system damage via direct virus-induced nerve damage or indirect host immune-mediated damage.

Long-term presence of the virus components within the brain in COVID-19 patients can contribute to autoimmune

and neurodegenerative diseases like Alzheimer's disease, Parkinson's disease and multiple sclerosis [3]. A 2020 review by Ladocola et al. implicates a significant long-term neurological toll post-COVID 19 infections [4]. In a retrospective case-control analysis, Wang et al. (2021) show the presence of a bidirectional relationship between viral infections and dementia [1]. Individuals with COVID-19 are at an increased risk of infection and due to their compromised health, enact a poor immune response which places them at an increased risk of dementia. Based on their findings, Wang et al. (2021) anticipate a higher prevalence of dementia in patients with COVID-19 along with worsening of dementia symptoms in survivors, untimately being housed in long-term care facilities[5]. The authors also emphasize the importance of a large nationwide database to help identify early trends in risk and outcomes of COVID-19 in dementia patients [1]. A longitudinal study by Liu et al. published in 2022 also identified an increased risk of being diagnosed with dementia within 6 months post-infection [6]. The mechanism by which this occurs is multifaceted. It is believed that long-lasting hypoxia may substantially contribute to post-infection cognitive decline, along with chronic systemic inflammation post-infection exacerbating neurodegeneration, leading to long-term cognitive defects. Studies also show that inflammatory factors also do not return to normal status post-COVID infection. There was additionally an increase in neurodegenerative biomarkers in COVID-19 survivors [6].

Incorporating the regular use of mobile applications is expected to decrease the prevalence of amnestic symptoms in elderly COVID-19 survivors as the practice of strategy-based memory and reasoning training is helpful for this demographic by promoting synaptic plasticity at the hippocampus [7]. Numerous studies have been able to demonstrate the application of visual virtual interfaces in modulating long-term synaptic potentiation at this site in the brain [7]. In turn, synaptic perturbation is tightly associated with overall network changes in signaling patterns across dendritic spines of neurons within the hippocampus, as well as an increase in neuronal firing rates across the structure [8]. Given the importance of the hippocampus in the processing and storage of episodic as well as semantic memory, it has been theorized that strengthening these connections through the integration of technological interfaces in therapeutic practice may contribute to delaying the onset of dementia [9].

The use of mobile applications as a strategy to combat the incidence of dementia in COVID-19 survivors has been developed to support individuals with the condition, along with their caregivers, in order to manage routines and enhance safety [10]. Furthermore, given the phenomenon of population aging that is currently present across several nations around the world, the incidence of various dementias is expected to rise dramatically [11]. As a result, systematically examining how this digital application can potentially decrease the prevalence of dementia in this demographic has the potential to revolutionize rehabilitation techniques [5].

In addition, the integration of databases documenting COVID-19 cases and co-morbidities both in individual hospital records as well as on a larger scale have been crucial to performing statistical inference regarding health decisions in the wake of the pandemic [12]. Therefore, the use of virtual applications in both therapeutic applications as well as for the mandated collection of health data to document cases may be beneficial to governing bodies to develop relevant health policies to address the growing onset of mental illnesses following infection of the virus [13].

Research Question

Given the increased severity of dementia in patients post COVID-19 infection, would the implementation of a mobile application designed to engage elderly patients in active recall via repetition on memories through visual virtual interfaces and consolidate patient health data help prevent the onset/progression of comorbid mental illnesses?

Hypothesis

Incorporating a virtual assistive intervention into the regular routine of elderly patients who survived a COVID-19 infection is expected to decrease the incidence of dementia in that population.

Aims/Objectives

This study aims to investigate the efficiency of implementation of a mobile application in delaying the onset/progression of dementia in patients with a history of COVID-19 diagnosis and centralizing patient health data in a singular domain in aiding the prevention of the onset of mental illnesses post COVID-19 infection.

Methods

This study should progress as a 6-year two-pronged randomized controlled trial collaborating with internal care unit departments at long-term care facilities across the Greater Toronto Area to collect a representative sample of people 65 years old and older with previous hospitalizations due to COVID-19, have access to a wifi-enabled device to begin with and can demonstrate some competency using this device without guidance or support from caregivers. [14,15]. A previous study that primarily used MMSE as a measure of the cognitive interventional outcome had a large final sample size of 3,915 further divided into groups which led to statistically significant results among groups. [16] Similarly, this protocol should also include a large sample size even after participant dropouts have been taken into account. Participants will be separated into a control group receiving no intervention at their respective long-term care residences, and a "full dose" experimental group receiving a beta-adaptation of an existing mobile application designed to promote hippocampal synaptic potentiation in

individuals experiencing cognitive decline 5 times per week for 15-minute durations each across 2 years. This application would be based on an existing iPad program, which uses repetition of memories through the use of a flashcard game using images and text details related to an event in the patient's own life, and can be used individually or with the help of caregivers. Repetition of important life events in this manner using active recall may be beneficial to patients to prevent the onset of memory loss characteristic of various dementias [17]. Taking into consideration the likelihood of potential crossover in assigned treatment designations, there will also be a "partial dose" experimental group associated with patients who may be receiving the intervention irregularly or not alongside the "full dose" experimental group designated to receive the application intervention.

Participants would also be asked at the pre-test state in both groups to complete a survey regarding their normal activities such as exercise level, any comorbidities, their education level, use of any other therapeutics and any family history of neurodegenerative disease. Participants would be followed-up at 6-month periods to receive a repeat neuropsychological exam, and each year to receive a structural 3D coronal T1 MRI to identify objective lobar neuroanatomical changes and atrophy at the medial temporal lobe related to the onset of various dementias until the end of the 6-year timeframe [18,19]. As part of the neuropsychological exam, participants will be administered assessments such as the Mini-Mental State Exam to evaluate cognitive function. Together, these measures would be used to construct a formal diagnosis of dementia with the help of clinical assessors in participants to effectively calculate the incidence of dementia in both groups across the study timeline.

Although longitudinal studies generally present with high rates of non-compliance among participants or patients not following their assigned grouping, collaborating with internal care unit departments at long-term care facilities across the Greater Toronto Area reduces this rate. Even so, patients will be encouraged to drop out of the study or stop using the application if they present symptoms of further neurodegeneration or mental strain from using the application.

Furthermore, caregivers and trained nurses at these long-term care homes will be asked every 6 months to perform a numerical evaluation of several components of the intervention regimen to assess the quality of life and compliance with the treatment protocol. At 1.5, 3 and 4.5-year milestones, results will be re-evaluated to determine the ethics and feasibility of continuing with the existing study.

Results

Based on previous literature published in this field, it is expected that patients receiving the intervention will experience lower rates of cognitive decline when compared to those in the control group.

MRIs are often used to examine various structural components of the brain as part of the diagnostic testing for dementia. Common clinical manifestation of dementia is characterized by cortical atrophy, where the brain's cortex degenerates. Continual neuron loss causes the normal wrinkled appearance of the cortex to become thinner, with the sulci or indentations of the cortex widening, in conjunction with expanding of the ventricles in the brain [20]. Such changes are expected to be more pronounced for the MRI scans of the elderly population in the control group in comparison to those in the "full-dose" experimental group.

The MMSE has been identified as an accurate tool to measure cognitive decline in a subset of 1141 patients [21,22]. Results showed that when a cut-off threshold score of <23 was obtained, there was an 89% classification of dementia among those patients. Therefore, based on the accuracy of the MMSE when used in public health settings, it can be predicted that patients' part of the intervention group will score above 23 on the MMSE compared to the control group. In addition, a study by *Jo et al.*, primarily used the MMSE as a measure of the cognitive interventional outcome for patients clinically diagnosed with dementia and non-dementia participants [16]. Trained experts ran the cognitive interventional program which involved exercise, music, cooking, storytelling, play as well as recall therapy in the form of either personal therapy or group therapy. A mean MMSE score increase of 0.7 points was observed in the non-dementia group, while an increase of 1.0 points was observed in the dementia group which is statistically significant from the latter. However, upon further subgroup analysis in the dementia group, there was an increase of 1.3 points among patients who completed more than 10 sessions of the cognitive intervention which is statistically significant compared to patients who completed under 10 sessions with an MMSE score increase of 0.41 points. Based on these results, it can be predicted that patients with dementia will increase by 1 to 2 points over the course of the treatment as measured by the MMSE depending on the length and consistency of the intervention.

More specifically, the consistent use of cognitive assistive technologies in long-term care facilities for patients with dementia post-COVID-19 infection may be credited for the success of such technology [23]. In a 2017 review by Klimova and Maresova exploring cognitive-focused therapeutic interventions for mild cognitive impairment and dementia patients in 4 randomized-control trials, it was found that, although only one study showed an increase in episodic memory alongside abstract reasoning, a majority of studies emphasized that many computer/technological focused cognitive interventions assist in slowing the rate of cognitive decline [24]. The study summarizes that the interventions are short-term

focused, and little is known about the long-term impacts and success rate of such cognitive interventions, therefore, to further support the efficacy of the technologies, an increased number of longitudinal randomized control trials (RCT) should be conducted. Hence, this protocol is designed to be long-term where results and progress will be re-evaluated at 1.5, 3 and 4.5-year milestones.

The well-accepted method of using digital technology is expected to support survivors with amnestic symptoms and caregivers in order to bypass physical and environmental issues during regular times, along with future waves of a pandemic. The intervention is hypothesized to be advantageous in terms of mental health, the learning of skills, and social aspects [11]. Based on a systematic review of 8 RCTs by Egan et. al, it was found that through these online applications, the mental health burden on caregivers is reduced [25]. However, in addition to this, some studies in the RCTs reported changes in caregiver burden outcomes, knowledge skills, quality of life, responses to challenges, coping outcomes as well as self-efficacy.

Not only is it expected that the rate of cognitive decline will be less for patients in the intervention group relative to those in the treatment group, but overall, those patients will experience more autonomy and independence, improving not only their quality of life but also providing a sense of relief to their family members and caregivers [26].

Discussion

It is critical to assess the therapeutic relevance of cognitive assistive technologies in elderly patients with dementia post-COVID-19 infection as the research can provide a better understanding of aging with dementia and caregiver practices. Technology-based interventions can collect prospective data on patients with dementia, model the risk factors associated with the condition, provide supportive monitoring, and engage the patient in activities that promote hippocampal synaptic potentiation. The aforementioned uses of technology-based interventions will equip clinicians with a greater understanding of dementia and how technology can be incorporated to improve the quality of life for such patients.

While MRIs and MMSE scans are commonly used by clinicians to diagnose and manage dementia, electroencephalogram or EEGs can also be used as well. By precisely recording and measuring the electrical activity of the brain waves, clinicians can determine any unusual patterns that may be indicative of dementia, more specifically the seizures associated with some form of dementia. Despite all procedures taking roughly the same amount of time to conduct, MRIs and MMSE scans are used more often than EEGs mainly due to the ease of use for the former scans.

Solely considering dementia as a clinical issue that is treated with long-term medications and hospital visits is not an adequate measure for the patients' quality of life. This framework used presently neglects to address many of the patients' demands and concerns and is not a preventative approach [4]. Therefore, with the advent of cognitive assistive technologies being introduced in long-term care facilities, a more holistic therapeutic approach is presented.

The implementation of cognitive assistive technologies in the treatment plan for elderly patients following a COVID-19 infection directly aligns with the principles of personalized medicine [23]. Consequently, it is important to evaluate each patient on a case-by-case basis to determine which technology would best suit their individual needs to reap the maximum benefits of such technology. It must be determined whether the patient would best benefit by having technology supplement personal care, completely replace personal care or any other combination. Presently, there is no assessment that can be conducted to determine the ideal extent of technology to be involved in a patient's care plan, posing a limitation to the proposed approach [26].

Evidently, there are cultural-related and healthcare-related differences present amongst patients, emphasizing a need for personalized medicine [10]. Previous literature involving the prevention of dementia using mobile phone applications organized an international RCT where participants were recruited from Beijing and the United Kingdom, increasing the external validity [10]. Although the core functionality of the mobile app and study design was consistent amongst the subgroups, certain logistics and layouts had to be culturally adjusted. This should be considered and emphasized when delivering this intervention to patients with dementia and their respective caregivers.

When considering gerontechnology, a major limitation surrounding this technology revolves around the age of the target population. Older adults tend to be less proficient with technology in comparison to other age groups. Hence, one of the issues that should be at the forefront during the development of the application is its user-friendliness to ensure that patients are able to reap the maximum benefit from this [11]. Furthermore, healthcare professionals will have to be trained on how to best use the technology so that they can go forward and help familiarize the patients with it.

While the advent of such a technology-based application will inevitably be of benefit to elderly patients who have dementia following a COVID-19 infection, the feasibility of incorporating this into the daily routine of elderly patients worldwide in long-term care homes must be taken into consideration. Hence, to maximize the benefits of assistive technology for dementia, strict policies must be devised that promote its consistent use and overall accessibility. Factors such as rapid development and testing, funding, strong technology support systems and more must be taken into consideration to ensure a seamless transition to increased reliance on technology for dementia patients [27]. Furthermore, there are certain financial

limitations that must be taken into account. Most health insurance plans have not been designed with this technology in mind, potentially resulting in patients having to rely on their personal finances to afford this technology [26].

Conclusions

Technology-based intervention holds a promising position in the concept of 'aging in place,' the capability to live safely, independently, and pleasantly in one's own home and community, irrespective of age, income, or ability level. The implementation of a mobile application designed to perform long-term potentiation is developed with the goal of supporting independence and autonomy, along with safety in order to accommodate ethical concerns [26]. Evidence suggests that technology is accepted and can help persons with dementia and their caretakers avoid physical and environmental challenges both in normal times and during future pandemic waves. To better the deployment of technology in everyday life while maintaining essential personalization so that the application caters to the individual needs of the patient, more and more standardized research is required [11]. While dementia is a spectrum of symptoms with numerous etiologies, making it challenging to definitively diagnose, such as Alzheimer's disease, until after death, it is difficult to determine particular recommendations for each type of dementia. There is presently no assessment that can be used to determine which technology or social media platform is accessible for people with certain dementias [26]. Rather, the decision to incorporate and integrate technology into daily life is a personal one based on personal needs and ambitions. As a result, additional long-term randomized controlled trials are required to demonstrate the efficacy of technological interventions in the form of mobile applications in older people with mild cognitive impairment and/or dementia.

List of Abbreviations Used

BBB: blood-brain barrier
COVID-19: coronavirus disease of 2019
RCT: randomized controlled trial
EEG: electroencephalogram

Conflicts of Interest

The author(s) declare that they have no conflict of interests.

Ethics Approval and/or Participant Consent

Due to the nature of the proposal, ethics approval and participant consent were not required.

Authors' Contributions

AS: Made contributions to the results and discussion of this paper. AS is to be held equally accountable for all other aspects including drafting the manuscript, critically examining it for its content and collectively approving the final version to be submitted.
MB: Made contributions to the results and discussion of this paper. AS is to be held equally accountable for all other aspects including drafting the manuscript, critically examining it for its content and collectively approving the final version to be submitted.
AA: Made contributions to the methods of this paper. AA is to be held equally accountable for all other aspects including drafting the manuscript, critically examining it for its content and collectively approving the final version to be submitted.
JP: Made contributions to the conclusion, aims/objectives, hypothesis rationale, clinical relevance, and hypothesized results section of this paper. JP is to be held equally accountable for all other aspects including drafting the manuscript, critically examining it for its content and collectively approving the final version to be submitted.
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