Developing Wearable Headband for Enhancing Slow Wave Sleep in Older Adults

(Technical Project)

Researching the Influence of Different Social Factors on Transportation Barriers to Healthcare Services in Rural Regions of the United States

(STS Project)

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By
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Health equity is the state in which everyone has a fair and just chance to achieve their optimal level of health. Obtaining this requires ongoing societal efforts to address the different social, economic, and historical obstacles that compound health inequities. Health equity goes beyond just one's access to adequate coverage, and consists of many different factors such as structural, transportation, and financial barriers. Transportation barriers to healthcare services and appointments represent a critical challenge in ensuring equitable access to medical services. In 2017, approximately 5.8 million Americans reported that transportation barriers prevented them from seeking proper medical care (Oluyede, et al., 2022). Transportation barriers to health care include lack of access to a vehicle or public transportation, inability to operate a transportation vehicle, long travel distances and times, and poor transportation infrastructures. Additionally, health care services may include access to pharmacies for prescription refills, urgent health services, and laboratory services. These barriers interrupt adherence with medical appointments and can lead some individuals from not seeking health care at all.

It is crucial to examine the factors that are potentially causing these transportation barriers because it can lead to an increase in health care costs and impact the quality of life for individuals who are in need of medical support (Wolfe et al., 2020). Lack of transportation can lead to delays in clinical interventions, chronic disease exacerbations, and unmet health care needs which can accumulate to poorer health outcomes and worsen chronic illnesses. Transportation barriers can also increase the costs of healthcare as people who lack personal vehicles may have to pay for taxis or ride sharing services to get to healthcare appointments, which can lead to high costs depending on the estimated trip time and demand of rides for the

given area. Additionally, individuals with little availability to transportation potentially have to miss work or school to get to their healthcare appointments, as they have to accommodate to the schedule of public transportation or other transportation options. This can lead to a negative impact on their financial situation and their ability to participate in other daily life activities.

In a way to make healthcare more accessible, I will be designing and programming a wearable headband that will make acoustic stimulation accessible to older adults in the comfort of their own homes. By creating a wearable device that will measure brain activity during sleep, older adults will be able to take their device home and use it every night or while napping. This will reduce the number of doctor appointments that patients with Alzheimer's or dementia will have to attend, therefore lessening the burden of having to constantly travel for routine visits. In my STS project, I will be focusing on the different social factors that influence transportation barriers to healthcare services in rural regions of the United States. This research will be conducted through various literature reviews and syntheses to compile research and examine potential overlaps, gaps, and intersections with transportation barriers to health care.

Technical Topic

Alzheimer's disease (AD) is a progressive neurodegenerative disorder that results in impaired memory and behavior of patients over time. It is the most common form of dementia, affecting more than 6 million Americans of all ages (*Alzheimer's Disease Facts and Figures*, n.d.). Due to the complexity of the neurodegenerative disease and the unknown causation, there has been a lack of a cure. However, there are several treatments that help improve the memory, awareness, and the ability to perform daily function of patients with AD. Pharmacological drugs such as galantamine and donepezil have been used by AD patients to mitigate symptoms and prevent the disease from worsening (Anand & Singh, 2013). These medications work to prevent

the breakdown of acetylcholine, a brain chemical that is associated with memory and thinking. Alternative treatments such as Cognitive Stimulation Therapy (CST) have also been tested as a non-pharmaceutical option. CST consists of one to two, hour long sessions per week where patients take part in stimulating activities that are proven to maintain memory and mental functioning. However, cognitive and stimulation-based therapies have produced inconclusive results as a viable treatment option (Carrion et al., 2018).

As a result of the ineffective, non-pharmaceutical AD treatment options, we plan to develop a wearable headband device that will identify the slow-wave sleep (SWS) stage to deliver acoustic stimulation via pink noise to increase memory retention in older patients with an onset of AD. To execute this project, we will design a device that is comfortable and easy to use for the patient using Fusion360. Additionally, the device will house the necessary electrodes and wireless hardware that will allow patients to comfortably wear the device while sleeping or napping. The device will also explore different open-source repositories in order to build and train a working codebase to detect SWS and hearing detection. In addition to the device, a supplementary mobile application will be developed. This will be used for patients to provide feedback to the disease team and also display tracked sleep data.

Alzheimer's can be characterized by the presence of amyloid beta plaques, aggregates of misfolded proteins that form in between nerve cells, and neurofibrillary tau tangles, insoluble twisted fibers found in brain cells. Both have been found to be associated with disruptions in SWS (Lee et al., 2020). SWS is the restorative phase of sleep that aids in memory reactivation and clears the plaque found in the tissue between nerve cells of patients with AD. Pink noise is a type of noise that creates lower waves that filter out high sounds and has been associated with enhancement of SWS. Furthermore, pink noise has been found to provide maximum stimulation

with less arousal response in patients. Increasing slow-wave activity (SWA) through acoustic stimulation has been found to improve memory retention and recall. The goal of the project is to successfully identify the SWS stage of sleep and subsequently deliver acoustic stimulation via pink noise to amplify SWS signals, thus assisting in the removal of plaques associated with AD.

The proposed technical project aims to address the overall issue of transportation barriers to healthcare by providing patients with a more at home accessible treatment option. This will in turn reduce the amount of visits to treatment centers or pharmacies, unlike other non-pharmaceutical treatment options. By bringing the treatment to the comfort of the patient's home, it will lessen the amount patients may have to rely on various transportation means, as well as the burden of having to constantly travel for routine visits. Additionally, by developing a device that aims to introduce a preventative solution starting from the early indications of the disease, it will hopefully mitigate cognitive decline and remove the need to enroll in further treatment plans. Removing the potential need for further treatments will therefore remove the need to have to travel to such treatment centers. This technical project will also aim to reduce transportation barriers to healthcare but providing more flexibility and convenience to patients on when they can use the device. Instead of having to schedule appointments during work or school hours to accommodate public transportation availability, they will be able to take part in this treatment at their convenience.

STS Topic

Transportation to health care services is a crucial step for ongoing health and is an area that is often overlooked. It is a pivotal role in ensuring access to health care, influencing both its quality and availability. Furthermore, it facilitates regular check-ups, preventative care, and follow-up appointments, all which is integral in managing chronic conditions and preventing

their escalation. A 2017 study estimates that approximately 5.8 million individuals in the United States miss or delay non-emergency medical treatment every year due to a lack of transportation to healthcare facilities (Wolfe et al., 2020). Lack of access to a vehicle or public transportation, inability to operate a transportation vehicle, long travel distances and times, and poor transportation infrastructures are all examples of transportation barriers to health care.

Transportation inequities have been long rooted in United States history. From the mid-1800s to mid-1900s, there were a plethora of state laws, constitutional amendments, and city ordinances that legalized segregation and discrimination in the United States. The years 1900-1920 brought a full extension of segregation to all southern public transportation (Brenman, 2007). These transportation inequities eventually transformed into inequities within the interstate highway system. Many African Americans workers were confined to inner city neighborhoods, leading them having to travel much further distances to reach the jobs in the suburban areas. Many of the interstate systems today continue to disadvantage certain social groups, by either limiting access to the interstate or not making them readily available (Brenman, 2007).

Addressing transportation barriers is essential for ensuring that health care is accessible and equitable for all individuals. A lack of transportation can lead to further exacerbating existing medical concerns or delaying a potential diagnosis and treatment. An analysis done by the National Health Interview Study (NHIS) revealed a much higher prevalence of conditions for those who missed care because of transportation problems (Wallace et al., 2005). For example, the prevalence of frequent headaches in children was found to be twice as high in those who frequently missed care due to transportation problems compared to those who did not. A study done in Washington state found that for every 100-mile increase in driving distance to a primary

care physician, the time to treat colorectal cancer increased to 14.6 days (Wercholuk, 2022), emphasizing the importance of having proper transportation to prevent increased need of care. Additionally, missing or delaying care can lead to more treatments in the future (Syed et al., 2013), leading to more financial burdens on the patients to not only pay for the treatment, but to allocate more money for transporting to the health care center. Access to proper transportation can also increase access to healthier food options and vital services which in turn promotes a healthier lifestyle and thus reduces the chances of developing chronic illnesses (Abrahamson, and Skillen, 2021).

Research Question and Method

To delve more about the issues with transportation barriers to healthcare, I will ask the following research question: How do different social factors influence transportation barriers to healthcare in rural regions of the United States? By evaluating what factors play a large role in this barrier, results could drive new policies and systems that can help transportation become more equitable for all individuals. To develop an answer to this question, I will be performing a literature review on several different articles and case studies. These articles will help compile research and examine the potential overlaps, gaps, and intersections with transportation barriers. Additionally, I will utilize the politics of artifacts STS theory to examine whether existing transportation systems favor a certain ethical value or promote a particular political order to further investigate the root causes of these transportation barriers to health care (Winner, 1980).

Conclusion

In my technical project, I will be designing and programming a wearable headband device that will deliver acoustic stimulation to patients with Alzheimer's disease or dementia in the comfort of their own homes. Unlike other common non-pharmaceutical treatment options,

this technical project will help reduce the number of in-person visits that need to be made. In the STS deliverable, I will be investigating how different social factors influence transportation barriers to health care services in rural regions of the United States. The findings from the deliverable can be used by health care professionals and care coordinators to gain a better understanding on how they can broaden their support to individuals experiencing transportation barriers to accessing adequate health care. Both projects will be used to explore the ways in which health care can be made more accessible to individuals to eliminate the transportation barriers they face.

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Citations

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