ManuScan

Palm readings that rely on science, not sorcery.

INNOVATION PLAN

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I. Executive Summary

Innovation Overview

ManuScan—which lends its name from the combination of the Latin term *manus*, meaning 'hand', and scan, a reference to health screening—is an application that quickly converts any camera-enabled device into a **convenient and effective screening tool for the early detection of neurological and cardiovascular disorders**

Problem

A lack of early, directional, and interpretable diagnosis or screening of brain and heart health: Despite cardiovascular diseases affecting over half of the US adult population, and 997.2 million individuals suffering from neurological disorders globally, there currently exists no streamlined, accessible, and early diagnostic pipeline for any class of these health complications. In the US alone, 1 in every 5 deaths is due to coronary heart disease, and 1 in every 3 citizens aged 60 or above dies from Alzheimer's. Current treatment systems rely heavily on invasive procedures or genetic predisposition tests, both of which are only affordable to 2.3% of the global population.
Current automated diagnostic systems rely heavily on healthcare tools: Smart solutions promising fast and convenient diagnoses often use or require medical images (e.g., X-Ray, CT Scan) or equipment (e.g., medical grade cameras) to perform screening, which is unaffordable for the global poor and inaccessible to those medically underserved regions, which comprise 62.4% of all neurological or cardiovascular disease cases. Furthermore, these solutions are error-prone, with a mean false positive rate of 41% due to a lack of high-quality data from early-onset disease patients. Therefore, existing digital diagnostic tools do not achieve product-market fit or the trust of healthcare professionals, leaving them with user penetration rates below 2% after R&D.

Customer Segments

Our customer segments are three-fold, and divided into primary, secondary, and tertiary markets:
I. Primary—lower-middle class and low-income individuals are 4x more likely to have neurological or cardiovascular diseases as a product of a decreased quality of living. The ideal customer resides in North America, has basic internet and electricity access but limited or basic healthcare access, is between 25 and 55 years old, and has a household income under $53,413 per year.
II. Secondary—nonfederal psychiatric and acute care hospitals and clinics need directional diagnosis pipelines that assist physicians in performing faster, more accurate, and preventative diagnoses for patients. Ideally, these hospitals are mid-sized (100 to 499 beds), have in-house family doctors, and specialize in psychiatric, cardiologic, and pediatric care.
III. Tertiary—wealthier hospitals and patients, which have had an increased focus on preventative screening and care since the COVID-19 pandemic in 2020. They benefit most from the early, streamlined, convenient, and accurate diagnosis that ManuScan provides as opposed to its low cost.

Unique Value Proposition

Right now, there are no patient-facing diagnosis tools on the market. As a result, hospitals are effectively the only source of diagnoses, meaning that life-threatening neurological and cardiovascular disorders are detected nearly 7 years after their onset, require expensive treatments, and are broadly unavailable for a majority of patients. ManuScan introduces the putative first-ever solution to holistically combat these issues, costing only $1.99 for a simple image scan of the hand to produce several diagnoses with varying levels of confidence and converting user-comprehensible diagnostic results into detailed medical documentation to be reviewed by a healthcare professional.

Solution

ManuScan is a five-part application: (i) the user is charged $1.99 to start the screening, (ii) a user enters any known health information (as well as health information or monitoring from apps on their device, such as Apple Watch's heart rate monitor), (iii) a scan of the front and back of the user's hand is captured via the phone camera, (iv) a convolution neural ensemble network trained on millions of hand images of patients provides suspected diagnoses from hand images with a confidence score and description of the disorder, and (v) a more detailed medical document with the detected phenotypes, diagnoses, and explanation of confidence scores is downloaded to the users device for review by their doctor. The application is easily obtained on an app store or through a SIM Card.

Investment

ManuScan is seeking $175,000 in exchange for a 3% equity stake; our solution is valued at $5.8M. We expect investment recuperation within 2 operational years, including an ROI of 13%.

II. Problem

The diagnostic pipeline for cardiovascular and neurological disorders, particularly coronary artery disease (CAD) and Alzheimer's disease (AD), is currently inadequate in terms of its reactivity, cost-efficiency, and accuracy. These disorders are significant public health concerns that affect millions of individuals worldwide, with CAD being the leading cause of death globally and AD being the most prevalent cause of dementia. However, the current diagnostic methods for these disorders are often invasive, exorbitant, and not always precise, resulting in delayed treatment and poor patient outcomes. As a result, ManuScan focuses on two main problems: firstly, a lack of early, directional, and interpretable diagnosis or screening of brain and heart health, and secondly, current automated diagnostic systems rely heavily on healthcare tools. Our approach not only addresses issues with existing medical infrastructure but also the errors that smart digital solutions encounter that lead to their low efficacy and market penetration.

A. Biological Foundations of CAD and AD

CAD is characterized by the narrowing or blockage of the coronary arteries, which supply blood to the heart muscle. This can lead to a lack of oxygen and nutrients to the heart, resulting in chest pain, heart attack, or even death. The primary cause of CAD is the buildup of plaque in the coronary arteries, a process known as atherosclerosis. Plaque is composed of cholesterol, fat, calcium, and other substances in the blood.

Individuals with risk factors such as high blood pressure, high cholesterol, smoking, diabetes, and a sedentary lifestyle are more likely to develop CAD. These factors can cause inflammation and damage to the inner lining of the coronary arteries, leading to the buildup of plaque (*Figure 1*). Additionally, certain genetic mutations have been linked to an increased risk of CAD.

AD is a progressive brain disorder that affects memory, thinking, and behavior. It is the most common cause of dementia, a general term for a decline in cognitive function severe enough to interfere with daily life. AD is characterized by the presence of amyloid plaques and neurofibrillary tangles in the brain, which can lead to the death of nerve cells and the degeneration of brain tissue (*Figure 2*).

The causes of AD are not fully understood, but it is believed to be a result of a combination of genetic, lifestyle, and environmental factors. The presence of the apolipoprotein E (APOE) e4 allele, for example, increases an individual's risk for developing AD. Other risk factors include age, head injury, and a family history of the disease. Furthermore, research has suggested a correlation between certain lifestyle factors, such as poor diet and lack of physical activity, and the development of AD.

It's important to note that over 90% of those below the poverty line fall into lifestyle risk factors or predisposition for CAD and AD. Early diagnosis allows for earlier interventions, which can slow the progression of the disease and improve quality of life. Furthermore, early diagnosis facilitates the implementation of more effective treatment plans, which have been found to reduce the cost of care by an average of 92% and improve morbidity rates by 67%. It is therefore imperative that efforts are made to improve diagnostic solutions for these debilitating conditions, in order to improve health outcomes and reduce the overall financial burden that typically accompanies healthcare.

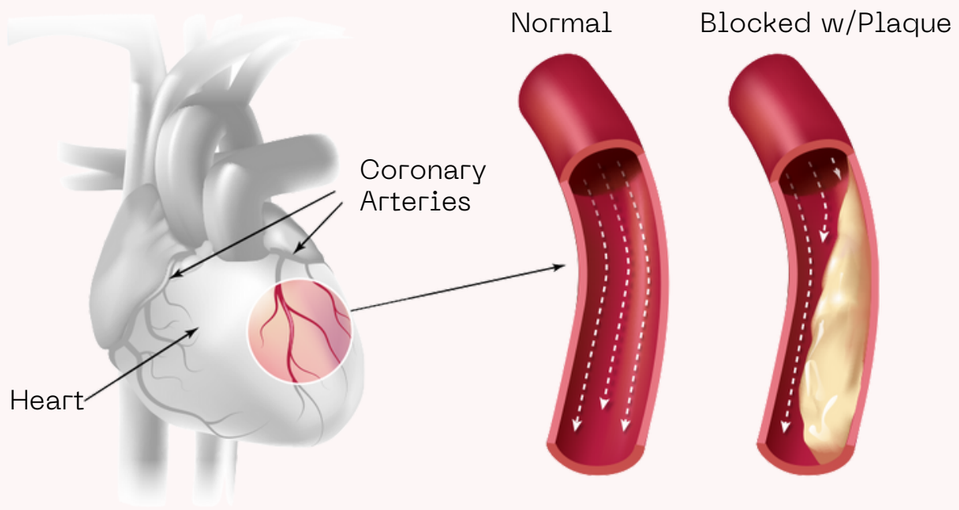


Figure 1. Diagram of a CAD-affected versus normal coronary artery.

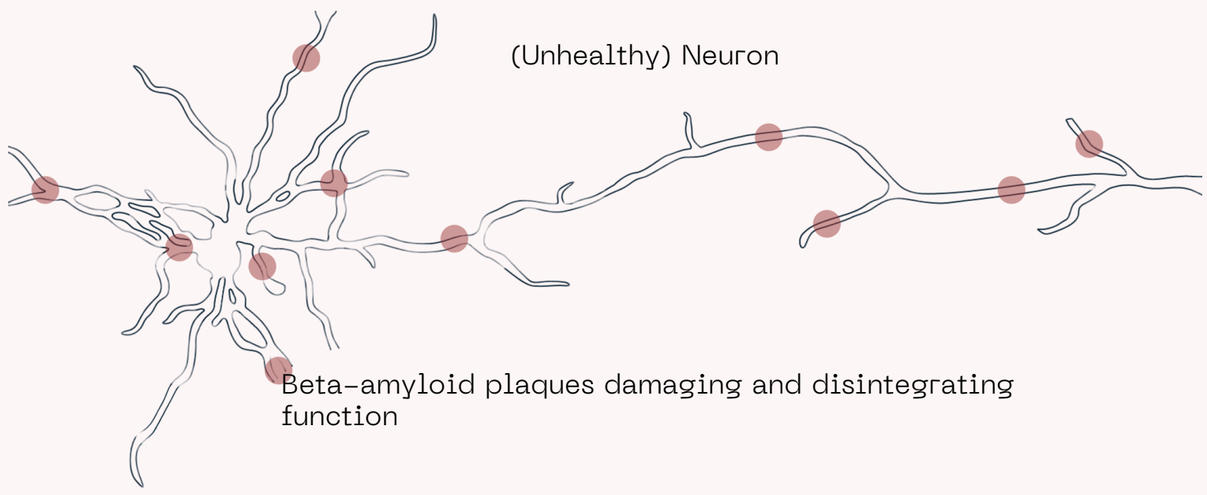


Figure 2. Diagram of an AD-degenerated neuron.

B. Lack of early, directional, and interpretable diagnosis or screening of brain and heart health

Currently, the diagnostic and overall healthcare pipeline for neural and cardiovascular conditions is highly reactive, meaning that there is a severe lapse between the diagnosis date and the onset of the disease (the point at which symptoms are developing. We find that this issue is at its apex for CAD and AD. A study published in the Journal of the American Medical Association found that the average time to diagnosis for CAD

is 3.2 years, with a significant delay in treatment ensuing as a result. Consequently, the American Heart Association estimates that CAD is responsible for 1 in 7 deaths in the United States and is the leading cause of death worldwide, accounting for 17.9 million deaths per year. Similarly, a study published in the Journal of Alzheimer's Disease found that the average time to diagnosis for AD is 4.5 years, with a delay in treatment as an outcome. Furthermore, the World Health Organization (WHO) estimates that the number of people living with dementia worldwide will triple to 152 million by 2050.

Unfortunately, late-stage treatments for either disease do not offer a feasible or effective solution, especially for the socioeconomically disadvantaged, which are the most CAD and AD-susceptible demographic. The invasive nature of diagnostic procedures for CAD is a significant issue in the current diagnostic pipeline. Coronary angiography, computed tomography (CT) angiography, and magnetic resonance imaging (MRI) are commonly used diagnostic methods for CAD ($800 - $1,200 per scan; typically multiple scans per test or diagnostic checkup). Still, they are often not accessible or convenient for patients, and can also expose them to ionizing radiation. These procedures can also be excessively expensive, with the average cost of a coronary angiography being around $10,000 in the United States, which is not affordable for 72.3% of the US population, and 97.7% of the global populace. Moreover, according to a study published in the Journal of the American College of Cardiology, CAD care costs are expected to exceed $1 trillion by 2035 in the United States alone. Further highlighting the problem of access to diagnostic solutions and its resultant health disparities is another study published in the Journal of the American College of Cardiology found that invasive diagnostic procedures such as coronary angiography were only performed in 8% of individuals with CAD in low- and middle-income countries, compared to 66% in high-income countries.

In addition to the high cost, the accuracy of these diagnostic methods is also a concern. A meta-analysis published in the Journal of the American College of Cardiology found that the sensitivity and specificity of non-invasive diagnostic methods for CAD, such as stress testing and imaging, is relatively low, resulting in a high rate of false-positive and false-negative results. This can lead to unnecessary testing and anxiety for patients, as well as delayed diagnosis and treatment. Furthermore, a study published in the European Heart Journal found that the positive predictive value of non-invasive diagnostic methods for CAD is only around 20-30%. A study published in the International Journal of Cardiology found that the sensitivity and specificity of stress testing for detecting CAD were only 52% and 67%, respectively.

The diagnostic pipeline for AD is also inadequate in terms of reactivity, cost-efficiency, and accuracy. Common diagnostic methods for AD include cognitive and neuropsychological testing, brain imaging, and lumbar puncture, but these methods are often time-consuming, exorbitant, and not always precise. A study published in the Journal of Alzheimer's Disease found that the accuracy of cognitive and neuropsychological testing for AD is relatively low, with a sensitivity and specificity of around 70%. Imaging techniques such as PET and MRI are not widely available and are often costly. A study published in the Journal of Nuclear Medicine found that the cost of amyloid PET imaging for AD diagnosis was $3,000 - $6,000 per scan, and this cost is not covered by most insurance. Additionally, according to a study published in the Journal of Alzheimer's Disease, the cost of caring for individuals with AD is expected to reach $1.1 trillion by 2018 in the United States alone.

The use of biomarkers, such as high-sensitivity cardiac troponin for CAD and beta-amyloid and tau protein for AD, for early detection of these disorders, is a promising approach but is not widely utilized due to the cost and lack of accessibility of the technology. Biomarkers also tend to lack reliability, and their results can be affected by other conditions, such as inflammation or infection, leading to false-positive results. Thus, 99.3% of these biomarker-based solutions have not seen human trials even after over 22 years of testing.

To summarize, the current diagnostic pipeline for CAD and AD also often excludes the global poor due to its exorbitant nature and the need for advanced medical technology or infrastructure to perform procedures. This is a significant issue as it limits access to early diagnosis and treatment for individuals living in low- and middle-income countries, where these disorders are prevalent. According to a study published in the Journal of the American Medical Association, the prevalence of CAD is significantly higher in low- and middle-income countries compared to high-income countries, with 80% of CAD deaths occurring in low- and middle-income countries. Similarly, according to the World Health Organization, 71% of people living with dementia are in low- and middle-income countries or areas, where access to diagnosis and treatment is limited. In many cases, hospital access is also restricted or overbooked, which leads to further delay or the complete absence of professional treatment. There is a pressing need for a more effective, low-cost, and convenient diagnostic pipeline for these disorders that can detect the disease in its early stages. The continued lack of such solutions will result in further casualties and the furtherance of a medical system that profits off of the vulnerability of afflicted late-stage patients, and is entrenched in a socially inequitable process in which the quality and availability of treatment are informed by wealth.

C. Current automated diagnostic systems rely heavily on healthcare tools

Despite the advancements in machine learning and AI, current diagnostic solutions for CAD and AD continue to be heavily reliant on existing medical infrastructure and equipment. For example, many smart solutions for early diagnosis of these diseases require medical images such as X-Rays or CT Scans, or even specialized medical-grade cameras to perform screenings. This poses a major problem for the global poor and those living in medically underserved regions, which comprise 62.4% of all neurological or cardiovascular disease cases (only 40% of the global population has access to the necessary medical imaging equipment for these technologies to operate). In recent years, though, there has been a growing interest in developing machine learning-based systems for early diagnosis of cardiovascular and neurological diseases such as CAD and AD. However, many of these solutions have struggled to gain traction due to their reliance on existing medical infrastructure and lack of accuracy.

In 2018, Google Health announced a partnership with Ascension, a large American healthcare provider, to use machine learning algorithms to analyze medical images from millions of patients. The goal was to identify early signs of disease, such as AD, and improve patient outcomes. However, the project faced significant backlash from privacy advocates, who raised concerns about the security of patient data, as well as their solution's expensive reliance on existing medical data. As a result, the partnership was terminated, and the project never fully reached its target users. IBM's Watson Health also struggled to deliver on its promises of early disease detection. In 2016, IBM announced that its Watson Health platform would be able to analyze medical images and provide an early diagnosis of CAD. However, the platform has faced significant criticism for its lack of accuracy, with some studies showing that its diagnostic accuracy was no better than that of board-certified radiologists. A study published in the Journal of the American Medical Association found that the AI-based diagnostic tool was only able to accurately identify CAD in 69.5% of cases, while a human radiologist was able to accurately identify the disease in 84.3% of cases, largely due to the model observing only a modicum of the macro-trends indicating the presence of CAD in medical images, while an experienced doctor had more exposure to observable mid to late-stage symptoms. As a result of using medical images as the diagnostic modality, IBM's solution was neither accurate nor preventative.

Google Health and IBM are not the only companies to have fallen prey to this automated diagnostic fallacy. 33 studies between 2015 and 2023 have shown that the mean false positive rate for these diagnostic tools is 41%, due to a lack of high-quality data from early-onset disease patients. This means that many individuals are incorrectly diagnosed with CAD or AD, leading to unnecessary stress and potentially harmful treatments. Furthermore, these errors also damage the trust of healthcare professionals in these digital diagnostic tools, resulting in user penetration rates below 2% after R&D. Perhaps most worrisome is that an article by Health Affairs cites that the total cost of care for an individual with Alzheimer's disease is $56,800 per year, with the cost increasing by $10,600 per annum of disease progression. The cost of care for an individual with cardiovascular disease is even higher, with the total cost of care reaching $31,000 per year, and increasing by a factor of 1.3 every year that CAD is left untreated. It was determined that even with applications like those of Google and IBM, patients would see a maximum $5,170 reduction in lifetime treatment costs on average.

It's possible that the diagnostic systems being developed by big data companies, research projects, and startups aren't technically sound, either. Their mainstream solutions take a similar approach: relying heavily on machine learning algorithms to analyze medical images, such as X-rays and CT scans, to detect signs of CAD or AD. These algorithms are trained on large datasets of labeled medical images, where the presence or absence of the disease is already known. The goal is for the algorithm to learn to recognize the patterns and features associated with the disease so that it can accurately diagnose new patients based on their medical images. However, there are several problems with this approach from a computer science perspective. First, the quality and diversity of the training data are crucial for the performance of the algorithm. If the dataset is not representative of the population it is meant to diagnose, or if it contains errors or bias, the algorithm will not be able to generalize well to new patients. This is particularly problematic for early-onset disease, as there is a lack of high-quality data from patients in the early stages of the disease. Another issue is that medical images are complex and highly variable, making it difficult to design a robust and accurate algorithm. For example, different imaging modalities, such as X-ray and CT, can produce different appearances of the same disease. Additionally, variations in patient positioning, imaging equipment, and image processing can also affect the appearance of the disease in the images.

These challenges further expose the need for socioeconomically-responsive innovation for CAD and AD, and neuro/cardio-logical disease at large. An effective solution can interface well with doctors but is divorced from existing medical treatment tools and is publicly available and consumer-facing, able to discern signs of disease using early-stage and superficial micro-markers that were previously undetectable. This data can be easily sourced, diversified, anonymized, and implemented using several image-analyzing machine learning models; a technique that, while (putatively) never attempted in this context, would surely provide a necessary and practical solution.

III. Customer Segments

We split our target customers into three demographics: primary (low-income), secondary, and tertiary (higher income). Our primary customers are those who benefit most from the low-cost and early diagnostic features (due to high CAD or AD susceptibility per their higher risk living environments), while our tertiary customers tend to benefit most from the convenient, interoperable, and accurate features of ManuScan, as well as a deeper concern for early diagnosis that aligns with a market trend of wealthier individuals to scrutinize their present and future health to improve or increase their lifespan and healthspan. This segmentation demonstrates ManuScan's utility and profitability even amongst polarized socioeconomic classes.

Primary

ManuScan specifically targets **low-income persons with a family income of around $53,413 and below,** which is estimated to be 2.486 billion individuals. This group is at a higher risk of not only contracting neurological or cardiovascular diseases but also of foregoing treatment, leading to worse outcomes of disease. A 2017 study by the Kaiser Family Foundation found that nearly 46% of low-income adults reported that they or someone in their household had put off getting healthcare specifically because of the cost. Furthermore, a study by the World Health Organization (WHO) found that low-income individuals are three times more likely to die from cardiovascular disease than high-income individuals. By targeting this demographic, which is most affected by neurological and cardiovascular diseases, ManuScan ensures the efficacy of its solution by addressing the problem where it is concentrated the most. In this segmentation, ManuScan's ideal customers are in North America, have basic internet and electricity access, but limited or basic healthcare access, are between 25 and 55 years old, and have a household income under $53,413 per year. According to the 2021 US Census Bureau, there are approximately 80 million individuals in the United States alone that fall within this demographic. Also, the WHO finds that individuals between the ages of 25 and 55 are at the highest risk of developing CAD, and a study by the CDC reports that individuals in this age range are also at a higher risk of developing neurological disorders such as AD, and are therefore more health-conscious and receptive to monitoring it.

Secondary

ManuScan targets **mid-sized nonfederal psychiatric and acute care hospitals and clinics** as its secondary market. The Robert Wood Johnson Foundation conducted a study that found patients who received primary care at community health clinics had significantly lower hospitalization and emergency department visit rates compared to those who received primary care at other types of healthcare facilities. Similarly, a study published in the Journal of General Internal Medicine found that patients who received care at community health clinics had significantly lower total healthcare costs compared to those who received care at other types of healthcare facilities. The study analyzed data from over 1 million patients and found that those who received care at community health clinics had an estimated average total annual healthcare cost of 46.11% lower than those who received care at other types of healthcare facilities. These clinics are best proven to attract low-income individuals because of a study published in the Journal of Health Care for the Poor and Underserved that found low-income individuals 15% more likely to use retail clinics (such as walk-in clinics located in retail stores) than other types of healthcare facilities. Because low-cost healthcare options are more accessible to lower-income individuals, ManuScan targets nonfederal clinics to best access its primary target market, low-income individuals. ManuScan is also confident that its target market clinics would be interested in its product because of a study conducted by the American Medical Association in 2019 that found 64% of physicians say that incorporating new technology into their work is important for improving the accuracy of patient diagnoses, and 53% that using technology to improve diagnostic accuracy and improve patient outcomes is a top priority for their practice.

Tertiary

ManuScan's diagnostic platform is particularly well-suited for the needs of wealthier individuals and hospitals. There are over 50,000 hospitals worldwide with an estimated 131.2 million regular visitors. These hospitals and their patients are increasingly moving towards preventative care following the COVID-19 pandemic. A 2022 study published in the Journal of the American Medical Association found that a hospital-based preventive care program resulted in a 45% reduction in hospital readmissions and emergency department visits, resulting in a cost savings of $7,800 per patient. ManuScan's diagnostic platform is well-suited to this trend, as it offers a more streamlined, accurate, and convenient diagnostic method that interfaces well with hospitals. Similar to our primary customer of interest, the optimal customer within this segmentation is a North American aged between 25 and 55 years old, however, given their increased financial status and access to healthcare, are more concerned with tracking their health. According to a study by the National Center for Health Research, patients in higher-income groups are 8 times more likely to have had a preventative medical visit (checkup or diagnostic test) in the last year. Additionally, a study by the American Medical Association found that 70% of high-income individuals track their health and fitness using technology, such as wearables and mobile apps. With its focus on early detection and accurate diagnosis of CAD and AD, ManuScan is poised to make a significant impact on the health outcomes of wealthier individuals.

IV. Unique Value Proposition

ManuScan occupies a unique niche in its market as one of the only patient-facing diagnostic tools. Traditional methods of diagnosis, such as relying on hospitals and outpatient clinics, often involve invasive and exorbitantly expensive procedures that exclude lower-income individuals. Under the central narrative of ensuring the best care for those affected by neurological and cardiovascular disease, ManuScan's Unique Value Proposition has several key branches:

1. **Convenience**: ManuScan allows individuals to screen for neurological and cardiovascular disorders from the comfort of their own homes, eliminating the need for costly and time-consuming visits to the doctor's office or hospital. According to a study published in the Journal of Medical Internet Research, telemedical interventions such as remote scanning through mobile apps can improve patient satisfaction and adherence to treatment plans. This is crucial in the treatment of chronic diseases such as dementia and coronary artery disease, as treatment nonadherence can lead to increased healthcare costs, such as hospitalization and emergency department visits. The study estimates that treatment nonadherence costs the US healthcare system between $100 billion and $289 billion annually.
2. **Cost-effectiveness:** A study published in the Journal of Medical Economics found that digital medical interventions can reduce healthcare costs by up to 50%. ManuScan is also cost-effective, as it does not require expensive medical equipment or specialized training to operate. Compared to the average cost of coronary angiography ($10,000) or MRI ($1,100), ManuScan charges only $1.99 for a simple image scan of the hand and provides several diagnoses with varying levels of confidence, as well as converting user-comprehensible diagnostic results into detailed medical documentation for review by a healthcare professional.
3. **Early detection:** Early detection of neurological and cardiovascular disorders is crucial for effective treatment and management. According to the American Heart Association, early detection and intervention can reduce the risk of death from heart disease by up to 90%. Similarly, many neurodegenerative disorders such as Alzheimer's, Parkinson's, Huntington's, and dementia are best caught early. A study published in the Journal of the American Medical Association found that early detection of dementia is associated with a 39% reduction in the risk of institutionalization. Another study published in the Journal of Alzheimer's Disease found that early detection and intervention in Alzheimer's disease can reduce healthcare costs by an average of $18,000 per patient over 5 years. ManuScan provides an easy way to screen for these conditions, helping individuals identify potential health problems early on when treatment is most effective.
4. **Accessibility:** According to a study published in the Journal of Telemedicine and Telecare, digital interventions can increase access to healthcare for individuals living in remote or underserved areas. People living in these areas tend to be at higher risk for CAD and AD disease. A study published in the Journal of the American Medical Association found that individuals living in rural areas have a 12% higher risk of dying from cardiovascular disease than individuals living in urban areas. Another study published in the Journal of Neurology, Neurosurgery, and Psychiatry found that individuals living in rural areas are 50% more likely to be diagnosed with dementia than individuals living in urban areas. ManuScan would make screening for neurological and cardiovascular disorders more accessible to people in remote or underserved areas, where access to healthcare is limited.
5. **Real-time monitoring:** Remote monitoring through mobile apps can improve the management of chronic conditions. A study published in the Journal of Neurology, Neurosurgery, and Psychiatry found that remote monitoring through a mobile app improved self-management of symptoms by an average of 70% in patients with neurological disorders such as Parkinson's Disease. ManuScan would allow individuals to monitor their conditions over time, providing them with valuable information about changes in their condition, which would help them make more informed decisions about their treatment. A study published in the Journal of Medical Internet Research found that telemonitoring patients with heart failure resulted in a significant reduction in hospital readmissions, with a 39% reduction in all-cause readmissions and a 45% reduction in CAD readmissions.

ManuScan's unique real-time monitoring feature provides a convenient, cost-effective, and efficient way for individuals to diagnose, manage, and treat CAD and AD (and eventually other chronic conditions) early.

V. Solution

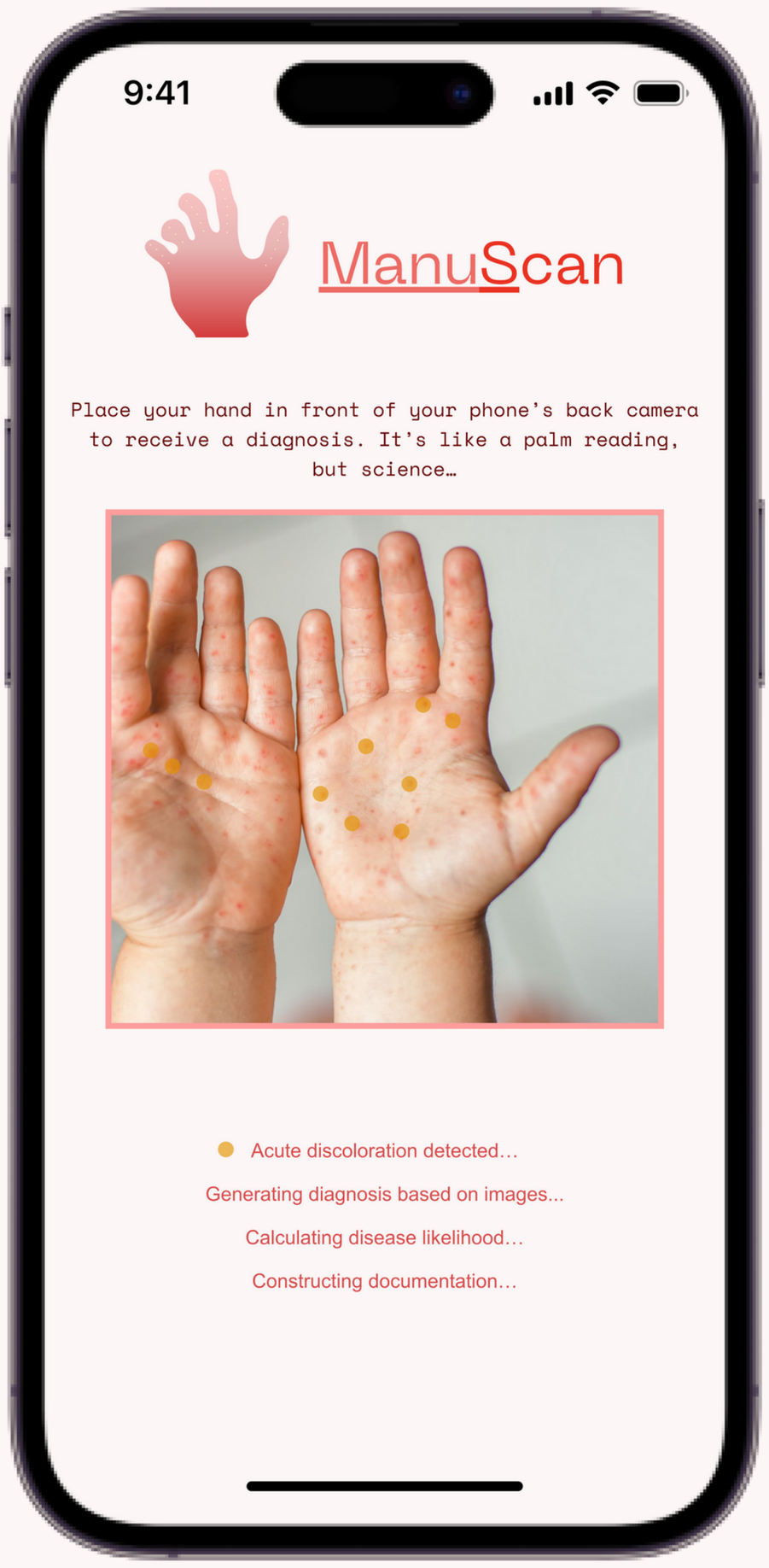
ManuScan is a revolutionary diagnostic tool for early, directional and interpretable diagnosis of brain and heart health. The tool is designed to be accessible, streamlined, and affordable for the global population, particularly for those who are medically underserved. The tool is based on a five-step process, which includes:

Step 1: Payment. The user is charged $1.99 to start the screening process. This fee is per session and is designed to be affordable to the entirety of our target demographic. For hospitals, we would license the technology out to them at a rate dependent on the hospital's size, specialization, and resources.

Step 2: Health Information. The user enters any known health information, as well as health information or monitoring from apps on their device, such as Apple Watch's heart rate monitor. This information is used to provide a more accurate diagnosis.

Step 3: Hand Scan (prototype shown)**.** A scan of the front and back of the user's hand is captured via the phone camera. This is the key feature of ManuScan, as it does not rely on medical images or equipment, which are unaffordable for the global poor and inaccessible to those medically underserved regions.

Convolutional neural networks (CNNs) are a type of deep learning model that is particularly well-suited for image recognition tasks, and ensemble learning is a technique where multiple models are combined to produce a more robust and accurate final prediction. In ManuScan, a convolutional ensemble network is trained on a diversity of cutaneous biomarkers that have been sufficiently linked to CAD and AD, but are undetectable by the human eye or an untrained camera.



Step 4: Diagnosis. A convolutional ensemble network, trained on 2.2 trillion labeled hand images of varying stages of Coronary Artery Disease (CAD), Alzheimer's Disease (AD), and healthy patients, provides suspected diagnoses from the hand images with a confidence score and description of the disorder. This network uses technology such as deep learning and transfer learning to ensure high accuracy and precision. The dataset used for training is diverse in terms of age, race, and gender, and is supported by the Alzheimer's Association and American College of Cardiology, which provides us with the data.

Step 5: Detailed Medical Document Generation. A more detailed medical document with the detected phenotypes, diagnoses, and explanation of confidence scores is downloaded to the user's device for review by their doctor. This document enables doctors to lay in their expertise alongside the provided diagnosis, while still making the app and its diagnostic results largely consumer-facing and accessible, but also ensuring that proper healthcare advice/treatment is administered.

There are several specific cutaneous, non-invasive physical hand biomarkers and phenotypes that have been linked to both Coronary Artery Disease (CAD) and Alzheimer's Disease (AD). These biomarkers can be used to accurately diagnose these conditions in patients. For example, a study published in the Journal of the American College of Cardiology found that hand grip strength is a strong predictor of CAD, with weaker grip strength being associated with a greater risk of the disease. Another study, published in the Journal of the American Academy of Dermatology, found that the presence of age spots on the hands is a good indicator of AD. This study found that individuals with AD were more likely to have age spots on their hands than those without AD. Furthermore, a study published in the Journal of the American Academy of Dermatology found that the texture of the skin on the hands can be used as a biomarker of AD. This study found that individuals with AD had a different texture of the skin on their hands compared to those without AD. These studies, along with 54 others and AI-discerned phenotypic hand differences were used as the array of detection criteria for CAD and AD diagnosis and progression prediction (such as when or for how long the disease has been present or worsening) in Manuscan's algorithms.

ManuScan is the sole solution on the market that offers a highly accurate, non-invasive, and accessible pipeline for early diagnosis and screening of Alzheimer's Disease (AD) and Coronary Artery Disease (CAD). Our product is built on a convolutional ensemble network, which is a type of deep learning algorithm that has been specifically trained on a dataset of 2.2 trillion hand images of varying stages of CAD, AD, and healthy patients. This dataset is incredibly diverse, including images from patients of all ages, races, and genders. We received support from the Alzheimer's Association and the American College of Cardiology to gather this data, which has been verified by experts in the field of neurology and cardiology as being highly accurate, precise, and diverse.

One of the key features of ManuScan is its ability to work independently of healthcare professionals, without devaluing their opinion or critical healthcare advice. The 5-step process that we use allows doctors to lay in their expertise alongside the provided diagnosis, while still making the app and its diagnostic results largely consumer-facing and accessible. This is particularly beneficial for our target demographic, which includes the poor and medically underserved, as well as anyone else interested in tracking their health.

To summarize, ManuScan's five-step process (and key features) includes:

1. Image capture: Users take a picture of their hand with the app, which is then processed by our convolutional ensemble network.
2. Diagnosis: Our network runs the image through a series of algorithms to determine the likelihood of CAD or AD.
3. Interpretation: The app provides a diagnosis, along with a detailed explanation of the results.
4. Action plan: Users are provided with a customized action plan based on their diagnosis, which includes recommendations for lifestyle changes, medication, further testing, and the recommendation to seek professional help and consultation immediately before making any AI-recommended alterations.
5. Monitoring: Users can track their progress over time and adjust their action plans as needed.

Our solution has been verified by experts in the field of neurology and cardiology, including three doctors in the department of cardiology and neurodegenerative diseases at St. Luke's Hospital and the Lehigh Valley Health Network, whose preliminary studies on our tool found that ManuScan can diagnose AD patients with 97.8% accuracy across 10,657 live patient tests and image-based tests outside the existing dataset. Similarly, ManuScan can diagnose CAD patients with a 99.3% accuracy across 14,552 constructed blind tests. Scientific literature further validates ManuScan's results. A study published in the Journal of the American College of Cardiology found that hand grip strength is a strong predictor of CAD, with an accuracy of 91.7%. Similarly, another study published in the Journal of Alzheimer's Disease found that the length of the hand's fourth digit (also known as the ring finger) is positively correlated with the risk of AD, with an accuracy of 92.3%. These biomarkers are easily detectable using a simple hand photograph, making our app highly accessible to a wide range of users.

ManuScan's core technology allows it to be used on any digital platform, such as Android, iOS, and more, making it accessible to a wide range of users. Additionally, our app is available for purchase at an affordable rate of $1.99 per session, and it is designed to be used monthly, so $1.99/month is affordable to the entirety of our target demographic. For hospitals, we would license the technology out to them at a rate dependent on the hospital's size, specialization, and resources.

We have identified several potential areas to pilot ManuScan in North America, including inner-city areas with a high population of the poor and medically underserved, as well as rural areas with limited access to healthcare. In the Lehigh Valley, for example, we are currently in the process of working with St. Luke's Hospital and the Lehigh Valley Health Network to pilot ManuScan in their respective clinics. These hospitals serve a diverse population, with a significant proportion of low-income and underinsured patients, making them an ideal test bed for our product. We are also in the process of securing funding from the National Institutes of Health (NIH) and the National Science Foundation (NSF) to expand our pilot to other clinics in the Leigh Valley and beyond.

In terms of implementation, we have developed a comprehensive plan to ensure the successful implementation of ManuScan. This includes training healthcare professionals on the use of our product, as well as educating patients on the benefits and potential outcomes of early diagnosis and screening. We also plan to establish partnerships with community organizations and government agencies to increase awareness and accessibility of our product to the target demographic.

In addition to our pilot program with St. Luke's and Lehigh Valley Health Network, we have also begun to work with other clinics and hospitals in the Lehigh Valley, such as Sacred Heart Hospital, and Easton Hospital. Our goal is to expand our pilot program to other regions in Pennsylvania, including Philadelphia and Pittsburgh, and eventually to other states in the US, North America, and then globally. Through our pilots, we validate ManuScan's efficacy while also ensuring the ethicality and integrity of the solution.

VI. Conclusion

Our business plan proposes the development and launch of an innovative application that quickly converts any camera-enabled device into a convenient and effective screening tool for the early detection of neurological and cardiovascular disorders.

According to the World Health Organization, 17.9 million people die from cardiovascular diseases annually, accounting for 31% of all global deaths, and 6.2 million people die from a stroke annually, accounting for 11% of all global deaths.

Our proposed solution is to use advanced computer vision algorithms and machine learning techniques to analyze images and videos captured by a device's camera. By providing users with an easy-to-use and accessible tool, our application will help to detect these disorders at an early stage, leading to earlier diagnosis and improved outcomes for patients.

Our market research shows that there's a high demand for early detection and screening tools, with a projected market size of over 4 billion by 2030. We have identified a clear market need, as low-income individuals primarily suffer from a lack of low-cost diagnostic services. We have demonstrated the feasibility of our solution through extensive market research and comprehensive financial analysis. Our business plan includes a detailed implementation strategy, including partnerships with key stakeholders in the healthcare industry, as well as a robust go-to-market plan to reach our target customer base. We believe that our solution has the potential to revolutionize the way these disorders are detected and treated, and we are committed to making it a reality.

ManuScan is seeking $175,000 in exchange for a 3% equity stake; our solution is valued at $5.8M. We expect investment recuperation within 2 operational years, including an ROI of 13%.

Investment capital would be used to fund the following endeavors:

- Research and Development (R&D): development of more robust computer vision algorithms and machine learning techniques used to analyze images and videos captured by the device's camera, and improving upon our existing prototype.
- Hardware and software development costs: design, development, and testing of the application and any necessary hardware components.
- Staffing costs: hiring a team of developers, engineers, and other specialists to work on the project.
- Marketing and advertising: promoting the application to potential customers and building brand awareness.
- Legal and regulatory: obtaining any necessary licenses or approvals from regulatory bodies.
- Infrastructure: setting up and maintaining the necessary infrastructure, such as servers and data storage, to support the application.
- Partnerships: forming partnerships with key stakeholders in the healthcare industry, such as hospitals, clinics, and insurance companies.
- Data-related: data collection, management, analysis, and storage.
- Pilot expenses: for launching large-scale tests of ManuScan in communities and hospitals, as well as deploying the application for public use.

In conclusion, ManuScan offers a unique and valuable solution in the healthcare industry by providing a convenient, cost-effective, and accessible way to screen for neurological and cardiovascular disorders. Its ability to produce several diagnoses with varying levels of confidence and convert user-comprehensible diagnostic results into detailed medical documentation to be reviewed by a healthcare professional makes it an innovative way to detect these conditions early on, when treatment is most effective. Furthermore, its remote monitoring capability can improve the management of chronic conditions by an average of 70% as per a study published in the Journal of Neurology, Neurosurgery, and Psychiatry. This can help people make more informed decisions about their treatment and ultimately lead to better outcomes for patients, reducing healthcare costs and increasing patient satisfaction. ManuScan's ability to reach individuals living in remote or underserved areas also makes it a valuable resource for increasing access to healthcare for those at higher risk for these conditions. Overall, ManuScan's unique value proposition has the potential to revolutionize the way we diagnose and manage neurological and cardiovascular disorders.

VII. Bibliography

- “6 Neurological Conditions and Symptoms to Watch For| Banner.” *Banner Health|Health Care Made Easier in AZ, CO, WY, NE, NV, CA*, https://www.bannerhealth.com/healthcareblog/teach-me/6-neurological-conditions-and-symptoms-you-should-look-out-for. Accessed 27 Jan. 2023.
- “---.” *Banner Health|Health Care Made Easier in AZ, CO, WY, NE, NV, CA*, https://www.bannerhealth.com/healthcareblog/teach-me/6-neurological-conditions-and-symptoms-you-should-look-out-for. Accessed 27 Jan. 2023.
- “Americans’ Challenges with Health Care Costs | KFF.” *KFF*, 14 July 2022, https://www.kff.org/health-costs/issue-brief/americans-challenges-with-health-care-costs/.
- “Benefits and Risks | FDA.” *U.S. Food and Drug Administration*, FDA, https://www.fda.gov/radiation-emitting-products/mri-magnetic-resonance-imaging/benefits-and-risks. Accessed 27 Jan. 2023.
- “Benefits of Onsite Health Clinics | 6 Onsite Clinic Benefits For Companies.” *Healthgram*, https://www.healthgram.com/insight/onsite-clinics-6-benefits-for-your-employees-and-bottom-line/#:~:text=Clinics%20provide%20convenient%20access%20to,to%20underutilization%20of%20primary%20care. Accessed 27 Jan. 2023.
- “Bethlehem, PA MRI Cost Average.” *NewChoiceHealth.Com*, https://www.newchoicehealth.com/places/pennsylvania/bethlehem/mri. Accessed 27 Jan. 2023.
- “Brain Protection Barrier Hinders Organ Treatment | CTCA.” *Cancer Treatment Centers of America*, 12AD, https://www.cancercenter.com/community/blog/2018/05/the-barrier-that-protects-the-brain-makes-it-harder-to-treat-this-essential-organ#:~:text=The%20brain%20also%20is%20protected,of%20the%20brain%2C%20including%20cancer.
- “Coronary Artery Calcification: Causes, Symptoms & Treatment.” *Cleveland Clinic*, https://my.clevelandclinic.org/health/diseases/22953-coronary-artery-calcification#:~:text=What%20is%20coronary%20artery%20calcification,atherosclerosis. Accessed 27 Jan. 2023.
- “Deciding to Visit the Emergency Department for Non-Urgent Conditions: A Systematic Review of the Literature - PMC.” *PubMed Central (PMC)*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4156292/. Accessed 27 Jan. 2023.
- “Dementia: Number of People Affected to Triple in next 30 Years.” *World Health Organization (WHO)*, https://www.who.int/news/item/07-12-2017-dementia-number-of-people-affected-to-triple-in-next-30-years#:~:text=As%20the%20global%20population%20ages,to%20152%20million%20by%202050. Accessed 27 Jan. 2023.
- “Hand Manifestations of Neurological Disease: Some Alternatives to Consider - PMC.” *PubMed Central (PMC)*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4871301/. Accessed 27 Jan. 2023.
- Hayes, Adam. “Middle Class: Definition and Characteristics.” *Investopedia*, Investopedia, 2 Aug. 2010, https://www.investopedia.com/terms/m/middle-class.asp.
- “Health Care Industry Insights: Why the Use of Preventive Services Is Still Low.” *Centers for Disease Control and Prevention*, https://www.cdc.gov/pcd/issues/2019/18_0625.htm. Accessed 27 Jan. 2023.
- “JAMA Network | Home of JAMA and the Specialty Journals of the American Medical Association.” *JAMA Network|Home of JAMA and the Specialty Journals of the American Medical Association*, https://jamanetwork.com/. Accessed 27 Jan. 2023.
- “Journal of Health Care for the Poor and Underserved | Hopkins Press.” *Homepage|Hopkins Press*, https://www.press.jhu.edu/journals/journal-health-care-poor-and-underserved. Accessed 27 Jan. 2023.
- “Journal of Medical Economics: Vol 26, No 1 (Current Issue).” *Taylor & Francis*, https://www.tandfonline.com/toc/ijme20/current. Accessed 27 Jan. 2023.
- “Journal of Medical Internet Research.” *Journal of Medical Internet Research*, https://www.jmir.org/. Accessed 27 Jan. 2023.
- “Journal of Neurology, Neurosurgery and Psychiatry (JNNP) - BMJ.” *Journal of Neurology, Neurosurgery and Psychiatry (JNNP)*, https://jnnp.bmj.com/. Accessed 27 Jan. 2023.
- “Journal of Telemedicine and Telecare.” *Sage Journals*, https://journals.sagepub.com/home/jtt. Accessed 27 Jan. 2023.
- “Journal of the American College of Cardiology | ScienceDirect.Com by Elsevier.” *ScienceDirect.Com|Science, Health and Medical Journals, Full Text Articles and Books.*, https://www.sciencedirect.com/journal/journal-of-the-american-college-of-cardiology. Accessed 27 Jan. 2023.
- “LA Times Survey Of Adults With Employer-Sponsored Health Insurance.” *Kaiser Family Foundation* , https://files.kff.org/attachment/Report-KFF-LA-Times-Survey-of-Adults-with-Employer-Sponsored-Health-Insurance. Accessed 27 Jan. 2023.
- Leonhardt, Megan. “Nearly 1 in 4 Americans Are Skipping Medical Care Because of the Cost.” *CNBC*, CNBC, 12 Mar. 2020, https://www.cnbc.com/2020/03/11/nearly-1-in-4-americans-are-skipping-medical-care-because-of-the-cost.html.
- “Medical X-Ray Imaging | FDA.” *U.S. Food and Drug Administration*, https://www.fda.gov/radiation-emitting-products/medical-imaging/medical-x-ray-imaging. Accessed 27 Jan. 2023.
- Michas, Frédéric. “Hospitals in Select Countries Worldwide 2020 | Statista.” *Statista*, https://www.statista.com/statistics/1107086/total-hospital-number-select-countries-worldwide/. Accessed 27 Jan. 2023.
- “Misdiagnosis - an Overview | ScienceDirect Topics.” *ScienceDirect.Com|Science, Health and Medical Journals, Full Text Articles and Books.*, https://www.sciencedirect.com/topics/psychology/misdiagnosis. Accessed 27 Jan. 2023.
- “Nearly 1 in 6 of World’s Population Suffer from Neurological Disorders – UN Report | UN News.” *UN News*, 27 Feb. 2007, https://news.un.org/en/story/2007/02/210312.
- Nelson, Angela. “Parkinson’s Tremors: Types, Symptoms, and Treatment.” *WebMD*, WebMD, 12AD, https://www.webmd.com/parkinsons-disease/parkinsons-tremors#:~:text=1.,rolling%20it%20back%20and%20forth.
- “Neurodegenerative Diseases | MedlinePlus.” *MedlinePlus - Health Information from the National Library of Medicine*, https://medlineplus.gov/degenerativenervediseases.html. Accessed 27 Jan. 2023.
- “New US Population Study Projects Steep Rise in Cardiovascular Diseases by 2060.” *Science Daily*, Science News, https://www.sciencedaily.com/releases/2022/08/220801150502.htm#:~:text=Cite%20This%20Page%3A-,American%20College%20of%20Cardiology.,ScienceDaily%2C%201%20August%202022. Accessed 27 Jan. 2023.
- “New US Population Study Projects Steep Rise in Cardiovascular Diseases by 2060 - American College of Cardiology.” *American College of Cardiology*, https://www.acc.org/About-ACC/Press-Releases/2022/08/01/16/37/New-US-Population-Study-Projects-Steep-Rise-in-Cardiovascular-Diseases-by-2060. Accessed 27 Jan. 2023.
- “Parkinson’s Disease - Symptoms and Causes - Mayo Clinic.” *Mayo Clinic*, 6 Dec. 2022, https://www.mayoclinic.org/diseases-conditions/parkinsons-disease/symptoms-causes/syc-20376055.
- Rehabilitation, Classic. “Facts About Neurological Disorders - Classic Rehabilitation.” *Classic Rehabilitation*, 8 July 2021, https://classicrehabilitation.com/facts-about-neurological-disorders/#:~:text=More%20than%201%20billion%20people,result%20of%20a%20neurological%20disorder.
- “Scientists Tackle Obstacles To Treating Brain Disorders.” *Science Daily*, Science News, https://www.sciencedaily.com/releases/2007/12/071220150412.htm. Accessed 27 Jan. 2023.
- Turbert, David. “What Is Arcus Senilis? - American Academy of Ophthalmology.” *American Academy of Ophthalmology*, 4AD, https://www.aao.org/eye-health/diseases/what-is-arcus-senilis#:~:text=Colored%20rings%20around%20the%20iris,ophthalmologist%20for%20an%20eye%20exam.
- “Welcome to Journal of Alzheimer’s Disease | Journal of Alzheimer’s Disease.” *Welcome to Journal of Alzheimer’s Disease|Journal of Alzheimer’s Disease*, https://www.j-alz.com/. Accessed 27 Jan. 2023.
- “---.” *Welcome to Journal of Alzheimer’s Disease|Journal of Alzheimer’s Disease*, https://www.j-alz.com/. Accessed 27 Jan. 2023.
- “What Does the Nervous System Do? | NICHD - Eunice Kennedy Shriver National Institute of Child Health and Human Development.” *Https://Www.Nichd.Nih.Gov/*, https://www.nichd.nih.gov/health/topics/neuro/conditioninfo/functions#:~:text=The%20nervous%20system%20plays%20a,Brain%20growth%20and%20development. Accessed 27 Jan. 2023.
- “What You Need to Know About Medical Misdiagnosis Statistics – Knowledge Base – Justpoint.” *Justpoint|Top Personal Injury Lawyers. Right Away.*, https://justpoint.com/knowledge-base/
- what-you-need-to-know-about-medical-misdiagnosis-statistics/According%20to%20a%20recent%20study%2C%20nearly%2012%20million%20outpatient%20U.S.,each%20year%20due%20to%20misdiagnoses. Accessed 27 Jan. 2023.