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Cardiovascular Disease and a Solution

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ABSTRACT

Heart disease has many variants, although its intimidating lethality remains prominent throughout. The problem, Heart disease plays a leading role in the U.S death toll. Although some heart diseases are man-ageable, the role heart diseases play in the annual death toll suggests a call for a cure. This paper will con-tribute to ongoing research in order to find a cure for heart disease, also known as Cardiovascular Disease. Many people find out they have heart diseases at a later stage, often resulting in more complicated ways for treatment to be implemented. When a patient enters the later stages of Cardiovascular disease chanc-es of survival remain relatively low. In detail, coronary heart disease is incurable but steps can be taken to reduce the effects of symptoms. Although why wait till one has inherited coronary heart disease? The solution, with advancements in technology we can concurrently look for evidence of developing symp-toms. This evidence can help doctors assign earlier diagnoses. Although one must understand the signs that must be looked for, ex: the buildup of plaque inside arteries, blood circulation levels, and respiratory levels. Since most of these symptoms remain hidden in our body, often causing late diagnoses we can use nanosensors to keep track and report this information. The further focus of this paper is not only to help readers understand the severity of heart disease but also to acknowledge a possible solution known as the nanosensor. Before understanding how nanosensors can help, it's important to understand that na-nosensors are a developing technology. Although, the potential to have an earlier diagnosis before the severity of the disease worsens remains unmatched in the world of health care. This paper utilizes the research method, combining articles and research papers alike in an effort to gather evidence to support the idea that Nanosensors can contribute to less deaths caused by heart disease. Nanosensors the focus of this paper is an explored solution, consisting of nanosized sensors that would provide biomarkers to help doctors analyze the likelihood of a patient inheriting cardiovascular disease.

Introduction

How can early treatment for one of the deadliest diseases known as cardiovascular disease be ensured to the population? Cardiovascular disease, also known as heart disease, plays a role as the leading cause for death in men and women reported in 2019. To put into perspective, another statistic by the CDC(Centers for Disease Control) states Cardiovascular disease is the leading cause of death globally, claiming 17.9 million lives each year.

With cardiovascular disease playing a crucial role in the staggering annual death toll, it is clear that many can benefit from earlier warnings. How do nanosensors help? The nano in nanosensor refers to its minuscule size, often allowing the nanosensors to be inserted in the bloodstream to provide bi-omarkers. Biomarkers are the biological indicators associated with the human body and can range from cholesterol levels to the presence of molecules. Biomarkers such as cholesterol levels are crucial and can help with the early detection of cardiovascular disease. This is because a higher cholesterol level is associ-ated with cardiovascular disease symptoms. Therefore, if the biomarker returns a higher cholesterol level, the chances of the subject having cardiovascular disease are evident. Knowing the usefulness of the bi-omarkers provided by nanosensors, “Why can’t we start implementing nanosensors right now?” Na-nosensors are relatively new technology, so gaps in their applicability are expected. For example, na-nosensors circulating in the bloodstream raise concerns such

as “How long will they circulate?” or “How many are needed in a bloodstream?” Furthermore, the biocompatibility of implantable nanosensors. Biocompatibility between a nanosensor and the subject is essential since after the lifetime of the na-nosensor has expired, it must be compatible with the surrounding tissue. Not only do nanosensors need to be biocompatible, they must act accordingly to minimize the immune system’s response to nanosen-sors. With nanosensors being an ongoing study, the potential of the biomarkers provided by nanosensors is clear. The ability to provide biomarkers can help detect early signs and assign treatments for cardiovas-cular diseases before symptoms and effects worsen. It is beneficial to obtain further warnings, and with many able to receive earlier treatments, the nanosensors will further reduce cardiovascular disease’s role in a nation's death toll.

Internationally, cardiovascular disease is put into perspective via its prevalence and deadliness. The global population can further benefit from utilizing nanosensors. While Cardiovascular disease isn’t contagious it still remains the most prominent disease globally. Emphasizing a need for nanosensor be-cause if nanosensors are released to the world, more of the population could benefit from earlier treat-ments, while also giving chances for innovators around the world to further improve accuracy and effi-ciency of the nanosensors. With improvements made and flaws adjusted the nanosensor holds potential to defeat and contain the power that Cardiovascular disease has on the world. Cardiovascular disease has shaped our world but also calls for change and innovation. Cardiovascular disease isn’t just a matter of genetics, it also relates to our habits. With habits being popularized globally such as lack of exercise and greater consumption of processed food items, the prevalence of Cardiovascular disease is understood.

At a national level, the National Library of Medicine states that nanomaterial-based biosensors can produce and detect various biomarkers with precise, simple and rapid efficiency. These biomarkers will place a heavy influence on the outcome of a diagnosis. With further insight provided by the National Library of Medicine on how nanosensors can help a nation, it becomes clear that further study on na-nosensors is necessary. The nanosensor's ability to provide “precise, specific, simple, and rapid strategies” for detecting early signs of cardiovascular disease helps put into perspective the effect nanosensors' im-plementation into healthcare would bring. Since the nanosensor can provide specific ways of identifying biomarkers associated with signs of cardiovascular disease, accuracy is ensured. Furthermore the terms “Specific” and “Simple” are used to describe the nanosensors approach to provide biomarkers, proving the efficiency of the nanosensor. At a national scale Cardiovascular disease still remains the deadliest, calling for a solution.

Zooming into a local setting, California follows the global trend of Cardiovascular disease being responsible for the leading cause of death. California Department of Public Health further reports in 2015 that cardiovascular disease was the leading cause of death in California, which begs the question, “Why?”. This is because the early stages of cardiovascular disease are not as identifiable as the later critical stages. Further leading to a later diagnosis resulting in delayed treatment; with the stage being critical, the chances for survival remain low. The key information needed to understand why Cardiovascular disease is so deadly can be found in a study published by the American Heart Association Journal, where it was discovered that participants of a test were found to have weakened heart muscles and narrowed arteries. Undiagnosed, these patients lived without being treated for heart disease. Further proving that Cardio-vascular disease can remain undetectable in its early stages. With cardiovascular disease being prevalent even locally, having nanosensors would benefit the community. A study done by the University of South-ern California shows nanosensors have the potential to identify the danger of plaque build ups by detect-ing abnormalities. These dangerous plaque build ups lead to strokes or heart attacks. With nanosensors being capable of pinpointing these plaques, doctors have an early chance to stop future occurrences of heart attacks or strokes.

Many people find out they have heart diseases at a later stage, often resulting in more compli-cated ways for treatment to be implemented. When a patient enters the later stages of Cardiovascular disease chances of survival remain relatively low. Further highlighting the importance of an earlier diag-nosis that can be obtained via the nanosensors. Nanosensors are said to be efficient and accurate when providing biomarkers which

are required for a diagnosis. For most doctors visual symptoms are required in order to deduce a diagnosis. Therefore, by learning and implementing nanosensors in healthcare, doc-tors would have an easier time diagnosing patients earlier. By having an earlier diagnosis, treatments would be more effective, and more lives would be saved. The significance of utilizing the Nanosensors potential to uncover early signs of Cardiovascular disease, one of the deadliest diseases globally, remains evident with the biomarkers that are provided by nanosensors. An earlier diagnosis correlates with earlier treatments and more lives saved, highlighting why nanosensors should be studied so implications are answered and nanosensors can be used to save lives.

Methods

With the main focus of this paper surrounding the exploration of mitigating lethality of heart disease with nanosensors, it's important for information to be accurate. This is why sources such as “WHO” (World Health Organization) and “NLOM” (National Library of Medicine) were used to ensure accuracy of the information. Both sources are highly trustable, this is because it is their responsibility to post accurate information regarding healthcare news, new advancements, etc, publicly for global viewing. The method includes utilizing such sources, extracting the key information, and implementing it to this paper helps to answer our research problem. How nanosensors can help combat the lethality of cardiovascular disease. While information on nanosensors is limited, public research papers give access to newly found infor-mation. With the incorporation of newly found information it helps maintain pace with new information being updated each day. Furthermore, conducting research on heart-disease remained simplistic due to the vast amount of information. Heart disease plagues the United States with a staggering death toll each year, emphasizing why information about symptoms, causes, and effects remains consistently updated.

Causes and Cure of Heart Disease

What causes heart disease? According to Heart and Stroke Prevention California and the World Health Organization, Heart disease can be inherited from family lineage although, even if heart disease is not present in one's ancestry it can still be inherited during one’s lifetime. For example unhealthy lifestyles can contribute to increased chances of obtaining heart disease. Not only lifestyle but stress, alcohol and lack of exercise also increase chances of obtaining cardiovascular disease. While we can’t directly cure cardiovascular disease we can lower the risk factors attributed with inheriting cardiovascular disease. For example, a newly developed drug has been discovered to lower your cholesterol levels. While the name of the drug hasn’t been stated its results emphasize its ability to lower cholesterol levels, lower than before. Unfortunately it may take more than just lowered cholesterol levels to beat heart disease. Although, by lowering cholesterol levels this may help postpone the likelihood of one obtaining coronary artery dis-ease. This is because higher cholesterol levels increase the chances of plaque being built up in the arteries. If plaque is built up in the arteries, blood flow will be constricted and the heart will be strained trying to receive or pump blood. By straining the heart, chances of heart attack are at an alltime high. This is where nanosensors are introduced. Nanosensors can prevent the severity of heart disease by reporting earlier diagnoses to ensure treatment. How nanosensors can help will be addressed further in the paper.

Lethality Rate of Heart Disease

Heart attacks result from heart disease and oftentimes before a heart attack occurs, symptoms are visual enough to anticipate a heart attack. For example, according to research done by Harvard Medical School, symptoms

include a crushing pain in the heart, chest pain, fatigue, shortness of breath, nausea, etc. The most common sign relates to problems or pain in the chest area as this can signify the clogging of the major arteries. While symptoms are visual it's too late, chances of survival remain low as the heart is under direct attack. Knowing one has heart disease by relying on the observation of external symptoms is unreliable. This is why observable biomarkers can help with changes to reduce risk factors. While we can reduce risk factors it is also important to understand doctors cannot erase the plaque buildup in arteries, highlighting the lethality of cardiovascular disease. Fortunately, those who have contracted cardiovascular disease don't succumb to mortality instantly. The times of death range from genetics, biology, health, and lifestyle choices. People can live with heart disease for a prolonged amount of time, although the heart becomes damaged. This is when heart failure, a serious condition, starts to develop. Although even with heart conditions people can survive with early detection of heart disease. The Early detection stemming from nanosensors can call for change in lifestyle habits, and medication. With change in lifestyle, specifi-cally exercise and diet, it puts less strain on the heart since healthier foods provide more energy and exer-cise increases the body's blood flow, ultimately lowering chances of heart attack. Also with early detec-tion, medication can be designated by doctors, to lower the chances of blood clots, lower glucose/blood sugar levels, and lower high cholesterol levels. Unfortunately there isn't much to be done about the ge-netic component since it cannot be altered or manipulated to change the rate at which the disease spreads. This highlights the importance of investing in a healthier lifestyle in order to reduce the chances of inheriting and surviving cardiovascular disease.

Focus Coronary Heart Disease

There are many types of different heart diseases, although the most common remains coronary artery disease. According to Mayo Clinic, a top ranked hospital in the U.S, most inheritance of coronary artery disease results from the buildup of plaque inside the coronary arteries cutting off the flow of blood. When the plaque starts to deteriorate, the plaque ruptures and results in the creation of blood clots resulting in chest pain, inevitably leading to a heart attack. Coronary artery disease affects the major blood vessels that supply blood to the heart. Since these major blood vessels carry the supply of blood to the heart, if damaged the blood supply would be unable to be received by the heart. When the heart does not receive blood, the heart muscle starts to weaken which further leads to heart attack. These major blood vessels get affected with the buildup of plaque, high cholesterol deposits. The buildup of plaque is referred to as atherosclerosis, often a result of the high cholesterol levels associated with a patient. Coronary Heart disease is a result of atherosclerosis, since plaque is commonly found to be built up in important arteries. Fortunately there are ways people can avoid atherosclerosis which saves the risk of obtaining Coronary Heart disease.

Nanosensors

A frightening statistic, stated by "One person dies every 33 seconds in the United States from cardiovas-cular disease" (CDC et al.,) emphasizes the lethality of cardiovascular disease. Why? It is further stated "About half of all Americans (47%) have at least 1 of 3 key risk factors for heart disease: high blood pres-sure, high cholesterol, and smoking" (CDC et al.,) showing that most people are already at risk for inherit-ing heart disease. Blood pressure and high cholesterol are observable data metrics, useful for diagnosing heart disease. Introducing Nanosensors, Nanosensors are relatively new technology and still remain under observation. For example because nanosensors are relatively new, this limits their applicability into bio-logical systems. Furthermore the reliability of the nanosensors is an ongoing question. Nanosensors also need to be biocompatible if its intended use is to be subject into one's body inorder for detection of dis-ease. This is because they will integrate with the surrounding tissue after its lifetime has expired. Na-nosensors garner a lot of attention, according to ACS pub-

lications nanosensors are a small portable de-vice, its impact on healthcare is too formidable to ignore. Nanosensors have been created with machine learning, the process of teaching Nanosensors what to look for in order to detect diseases. By giving na-nosensors data such as correlation of high cholesterol and the likelihood of cardiovascular disease, na-nosensors can give earlier diagnosis than modern day laboratory analysis. Nanosensors have gained great attention, spanning its influence throughout the medical, biological, and chemistry communities. This is because infectious diseases are quite prominent in modern society, many concerns are brought up with containing the spread. Nanosensors use nanomaterials and biosensing technologies in order to detect these infectious diseases in an effort to contain the spread.

Purpose of Nanosensors

According to Nanowerk, Nanosensors are created to report physical, chemical, biological or environmen-tal information for data analysis. Nanosensors come from Nanotechnology, designed to deal with physical and chemical properties at nanoscale. They have been tested and proved to result in identifying nanostructures. Nanostructures can consist of molecular structures, molecules such as hydrogen. A test included that nanosensors can also detect gasses, chemical and biochemical variables. Nanosensors come in a variety of looks and sizes. For example, according to Science Direct, there are physical, chemical, elec-trical and optical nanosensors. Physical nanosensors have the purpose of reporting physical statistics such as temperature. Chemical nanosensors are used to identify chemical values, such as pH levels. Elec-trical and optical nanosensors both observe chemical and physical attributes/biomarkers although elec-trical nanosensors measure voltage whereas optical nanosensors observe light.

How Do Nanosensors Help

The use of nanotechnology for early detection of diseases isn't new in healthcare. According to the Na-tional Library of Health, Nanotechnology can help with prognosis, defined as a prenotion for the likeli-hood of disease development, earlier treatment to decrease the mortality rate caused by disease. If a disease is treated during earlier stages the lethality of the disease significantly decreases, oftentimes in-creasing chances of survival. Nanosensors can be applied for disease detection to exhibit desirable results such as biocompatibility and the reporting of biomarkers . Moreover, keeping in-mind the observable internal levels associated with early signs of heart disease, such as cholesterol levels, Nanosensors can help to provide real time tracking of such levels. How would this work? For example,, Chemical nanosen-sors may be inserted into the human bloodstream. According to an article, Types of Nanosensors pub-lished by Jonathan Kristiansen chemical nanosensors would recognize cholesterol molecules via the use of machine learning, and nanosensors would be able to bind to the cholesterol molecules. While binding to cholesterol molecules nanosensors would emit a signal, traced by observing medical professionals. The intensity of the signal can then be used to depict the value of cholesterol levels. For example higher signal frequency would be interpreted as high cholesterol levels. If cholesterol levels are high, health profession-als would be able to diagnose healthier lifestyle changes to alter/reduce these levels. This earlier warning for the potential of heart disease would help decrease heart rate lethality. For example, initially high cho-lesterol levels can be combated with increased exercise levels, avocados, or oats. By creating lifestyle changes the chances for inheriting heart disease decrease ultimately relieving one from risk and lethality of heart disease. There are other types of nanosensors that can be applied to detect heart disease. Not only chemical nanosensors have the potential to detect biomarkers of heart disease, but optical nanosen-sors. Optical nanosensors would work in the same way. After being inserted to the bloodstream, optical nanosensors would be able to recognize cholesterol molecules optically rather than relying on molecule receptors like chemical nanosensors. Nanosensors can remain stationary, or circulate in the blood with-out harm. They can also provide

real time data for concurrent monitoring. When a nanosensor's lifetime is depleted it is imperative that they are biocompatible and can safely bind with surrounding tissue.

Exploring Possibilities

While there are many nanosensors that are able to produce biomarkers that help with earlier diagnosis, narrowing down a specific one best for cardiovascular disease isn't so easy. This is because each nanosen-sor is better than another depending on the situation. Nanosensors are developed with prenotion and cannot be modified to change its methods of detection. The way one builds a chemical nanosensor differs from the way an optical nanosensor. According to the National Library of Medicine, chemical nanosensors may be better for molecule selectivity while optical nanosensors are better suited for more efficient re-sponse times. Not only do the pros differ, the way nanosensors detect biomarkers differs vastly. Some suited better for specific situations than others. For example some nanosensors are better designed to detect and report intended biomarkers(molecules/levels). Also, purpose plays a role in selecting which nanosensors are best applicable. For example not all nanosensor deployments may be intended for earlier diagnosis, some could be intended for internal imaging.

Other Diseases/Limitations

Can nanosensors be used for the earlier detection of other diseases? The answer is definitely, nanosen-sors aren't tailored to be a solution for a singular disease. The only difference when utilizing nanosensors for other diseases, is the alteration of selected biomarkers one wants to look for. For example in sickle cell cancer, nanosensors may use machine learning to understand what molecules(biomarkers) to look for. These molecules will differ from the ones looked for in cardiovascular disease. While nanosensors seem like the cure for all diseases, it's important to understand the implications of nanosensors. Nanosensors come with conflict, reported by The Institute of Electrical and Electronic engineers, they are still weak in certain areas. For example the signals the nanosensors must transmit may not be as strong or there is noise interference. This creates the need for ways to generate larger/strong signals as well as creating ways to reduce the impact noise has on the biosensors reports. It is vital to understand ongoing concerns and address them before further implementation.

Discussion

Nanosensors can be applicable to a variety of other diseases, the deciding factor is the biomarkers na-nosensors need to look for. A nanosensor's applicability to other diseases is only limited by the nanosen-sor's ability to detect certain biomarkers. For example, if a certain disease to be detected requires the detection of the creation of larger molecules, some nanosensors may have trouble with this. Furthermore nanosensors may have trouble detecting diseases that create low levels of biomarkers. This is present in Alzheimer's disease, where there is low concentration of amyloid-beta peptides and tau protein making it hard for nanosensors to report the surgance of molecules. The inability to report such biomarkers may result in fraudulent results, the diagnosis may come out to be negative even though signs of the disease development exist, although they are not detected. This is another implication with nanosensors. Na-nosensors are unable to detect every biomarker they are tasked with. Moreover nanosensors are still relatively new, there isn't much data on the applicability and success of the nanosensor. However, when taking a look at the projection off the nanosensor market provided by "future market insights", from 2023 - 2033 we see a trend. In 2023 the nanosensor market reached a staggering 759.4 million U.S dol-lars whereas in 2033 its projected to reach double, 1,512.5 million U.S dollars. Within 10 years the na-nosensor market seems to double showing much investment made, publicly the potential of nanosensors is understood. This metric doesn't just encompass the healthcare use of nanosensors, nanosensors can also be

used to help soldiers detect harmful substances such as toxins or lethal explosives. Showing na-nosensors have expanded throughout many industries. Not only have nanosensors developed into other industries, in June 2022 company LiveMetric made a breakthrough innovation that measured one's blood pressure over 10 intervals. While this innovation does not include nanosensors that can be inserted into the bloodstream, it provides insight that society inches closer each day to the applicability of blood circu-lating nanosensors.

Conclusion

To conclude, the variety of nanosensors have a wide applicability. Whether it's detecting the resurgence of differing types of disease or being applied to different industries with the intent to benefit, nanosen-sors shouldn't be overlooked. The market for nanosensors shows a public understanding of the potential nanosensors hold to revolutionize the world. Diving in closely we see how nanosensors with future ad-vancements have the potential to mitigate the lethality and constraining grip cardiovascular disease holds. With cardiovascular dis-ease being one of the most prominent causes of death it's important to consider nanosensors as a possible solu-tion. Although the deployment of nanosensors, while very benefi-cial, still remains constrained by certain im-plications. Fortunately nanosensors are applicable to cardio-vascular disease, but this doesn't make nanosensors applicable to all diseases. Nanosensors can still be implemented to detect the resurgence of other diseases. With the potential nanosensors hold, the boom-ing market, and wide variety of applicability this paper further con-tributes to research efforts in order to explore possible solutions to lethal diseases utilizing our growing tech-nology.

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References

Top 10 causes of death in men. (n.d.). https://dph.illinois.gov/topics-services/life-stages-populations/mens-health/top-10-causes-death.html#:~:text=American%20heart%20 Association)

World Health Organization: WHO. (2019, June 11). Cardiovascular diseases. https://www.who.int/health-topics/cardiovascular-diseases#tab=tab_1

Lighting up cardiovascular problems using nanoparticles. (2019, December 19). ScienceDaily. https://www.sciencedaily.com/releases/2019/12/191209161147.htm

Heart Risk & prevention. (n.d.). Heart and Stroke Foundation of Canada. https://www.heartandstroke.ca/heart-disease/risk-and-prevention

Clinic, C. (2023, December 11). Can heart disease be cured? Cleveland Clinic. https://health.clevelandclinic.org/is-heart-disease-curable

Premier Heart and Vein Care. (2023, November 27). Vein Doctor in San Luis Obispo, CA | Ken Stevens, M.D. https://www.premierheartandveincare.com/

Heart. (n.d.). Heart and Stroke Foundation of Canada. https://www.heartandstroke.ca/heart-disease/

Harvard Health. (n.d.). Heart disease: Knowing different types and how to prevent it - Harvard Health. https://www.health.harvard.edu/topics/heart-disease

Heart disease - Symptoms and causes - Mayo Clinic. (2022, August 25). Mayo Clinic. https://www.mayoclinic.org/diseases-conditions/heart-disease

Heart Disease Facts | CdC.gov. (2023, May 15). Centers for Disease Control and Prevention. https://www.cdc.gov/heartdisease/facts.htm

Leong, Y. X., Tan, E. X., Leong, S. X., Koh, C. S. L., Nguyen, L. B. T., Chen, J. R. T., Xia, K., & Ling, X. Y. (2022). Where Nanosensors Meet Machine Learning: Prospects and Challenges in Detecting Disease X. ACS Nano, 16(9), 13279–13293. https://doi.org/10.1021/acsnano.2c05731

PubMed. (n.d.). PubMed. https://pubmed.ncbi.nlm.nih.gov/

Berger, M. (n.d.). Nanosensors – what they are; what they do. https://www.nanowerk.com/nanosensors.php#google_vignette

Kristiansen, J. (2021, June 14). Types of nanosensors. The Nano Future. https://www.thenanofuture.com/types-of-nanosensors/

AZoNano. (n.d.). Nanotechnology | Applications | Nanotechnology Companies. https://www.azonano.com/

Detection of weak nano-biosensor signals corrupted by shot noise. (2013, August 1). IEEE Conference Publication | IEEE Xplore. https://ieeexplore.ieee.org/document/6720842

Nanosensors Market. (2023, August 7). https://www.futuremarketinsights.com/reports/nanosensors-market