**Program and Policy Track:** Correlation between Rural Cardiovascular Disease Mortality and Environmental and Socio-economic Factors *A multi-step initiative to decrease rural CV Mortality* 

Shruthi Lingam-Nattamai

# Background Information and Context:

The leading cause of death in the United States is Cardiovascular Disease at 702,880 deaths per year. Cardiovascular (CV) mortality can occur from various diseases but atherosclerotic heart disease remains the major contributor to increased deaths. Throughout the United States, cardiovascular health has been on a decline. Overall, the gap between urban and rural deaths has been increasing steadily, with cardiovascular diseases being at the forefront of this gap (FIGURE 1). Cardiovascular deaths rose 21% in rural communities for ages 25-64 yrs, while in urban populations for those 65+ the incidence decreased 9% according to an AHA study.

In this analysis, we are going to explore the correlation between cardiovascular mortality in Washington State along with economic and environmental determinants.





# The Problem:

Since 2010, the 2nd highest leading cause of death has consistently been Heart Disease in Washington State (Next to malignant neoplasms at #1). From 2020 to 2022, age-adjusted cardiovascular disease mortality in Washington increased 3.5% and has been on an upward trend reaching 192.67 deaths per 100,000; similar to that of 2013 (189.27 deaths per 100,000) and

2014 (190.08 deaths per 100,000) according to WTN data. According to the WTN maps, cardiovascular disease mortality is even worse in rural counties/census tracts, such as census tracts in Adams, Whitman, Columbia, Yakima, Pend Oreille, Ferry, Stevens, Lewis, Grant, and Wahkiakum counties. Furthermore, counties in Southeast Washington (Adams, Benton, Whitman, Grant, Columbia) suffer from a lack of clinics in that area.

Figure 2: Age-Adjusted Washington State Census Tract Map for Cardiovascular Disease Deaths per 100,000 from 2016-2020 (top) and Bar Graph of Age-Adjusted Rate of Cardiovascular Disease Mortality per 100,000 in Each Washington State County (bottom).



Age-Adjusted Rate of Cardiovascular Disease Mortality per 100,000 People in Each WA State County



Figure 3: Age-Adjusted Washington State Census Tract Map for Cardiovascular Disease Deaths per 100,000 from 2016-2020 Overlaid with the Number of Clinics in Washington State, represented as a purple triangle (top) and Map of Cardiologists per 100,000 in Washington State Counties, 2020 (bottom).



The above 4 graphs (Fig 2 & 3) highlight where cardiovascular deaths are the highest in each respective census tract. The darker the color, the more deaths that are in the area. Figure 2's graph is on a scale of 5 colors while Figure 3's graph is on a scale of 10 colors increasing in darkness. Figure 3's graph also shows an overlay of purple triangles, which each signify clinics in Washington State during that period. It is clear that most clinics are concentrated in urban Western Washington, such as Thurston, Pierce, King, and Snohomish counties.

This is especially alarming because of the lack of clinics where the highest rates of cardiovascular disease mortality are noted. Additionally, many of the rural counties that are most heavily affected by cardiovascular disease are the counties with the least number of cardiologists, which would force them to travel to another county to obtain specialized treatment. For example, Adams, Franklin and Grant counties have too few cardiologists to even be measured on this map. Furthermore, cardiovascular disease and cardiovascular disease mortality come from the result of diet, exercise, environmental factors such as pollution, wildfires, lead exposure, and socioeconomic factors, such as poverty. Combined with this, the observed lack of clinics and cardiologists in rural areas to provide the appropriate care are detrimental to what would be known as a controllable cardiovascular event or disease. In other words, diseases that would otherwise be easy to control given an abundance of resources (in this case, proximity to a health clinic) is incredibly difficult to stop when barriers for patients to get the care they need are high.

Cardiovascular mortality can be reduced in these areas by understanding the driving factors behind the disparities between the different counties. We analyzed the most common socioeconomic factors and environmental factors to find various reasons why cardiovascular disease mortality was higher in rural areas.

# Economic Determinants:

Cardiovascular disease is not difficult to control, especially with technological advances over the years. The emergence of the percutaneous interventions, increased cardiologist consultations, primary care physician visits, and new medications, allows cardiovascular disease mortality to be curbed. However, that cannot be the case if rural communities are heavily affected by various environmental (air pollution or heavy metal exposure) and social determinants, such as poverty or low health insurance rates.

Figure 4: Census Tract Maps of Washington State's Population Living in Poverty 2015-2019 (top) and Population without Health Insurance 2013-2017 (bottom).



In the above maps (Fig 4), it is seen that poverty and populations without health insurance are more common in rural counties of Washington rather than the urban counties. Notably high uninsured counties include: Adams County with an uninsured rate of 27.8%, Franklin County with an uninsured rate of 22.4%, and Yakima County with an uninsured rate of 21%. Overall, not having health insurance or being below the poverty line makes it incredibly difficult for Washington residents to get to doctor's appointments due to their lack of transportation (and the distance at which they have to travel to get to a healthcare facility) or the overwhelming amount of various other responsibilities one may have, such as a constricting work schedule. This in turn creates worse health outcomes in rural areas, including for individuals with cardiovascular disease.

#### Environmental Determinants:

In parallel, various environmental factors have played a major role in worsening cardiovascular disease. While new technology helps improve cardiovascular disease mortality, a setback includes the various environmental hardships our world is going through. As wildfires become more prevalent than ever, gas vehicles are used more than ever before, and farming relies more and more on big monocrop farms rather than small local farms, small particulate matter and air pollution have been increasing heavily.

*Figure 5: Census Tract Map Prevalence of Wildfire Smoke from 2017 to 2023 (top) and Cardiovascular Disease Deaths per 100,000 from 2016-2020 (bottom).* 



*Figure 6: Washington State's Census Tract Map for Air Stagnation (accumulation of pollutants) in 2020.* 



Figure 7: Census Tract Map for Small Particulate Matter Concentration (PM 2.5) from 2014-2017. Green outlines signify various census tracts while the darker the purple area, the higher the concentration is.



In the above 3 graphs it is good to note that while both urban and rural communities are hard hit by PM 2.5 and air stagnation, rural communities, combined with the other hardships they have to face, are especially vulnerable to air pollution such as this. Furthermore, more rural communities in Washington State are affected by wildfires simply because of the geography of the state. The darker the shade of purple/red the census tract is, the more affected by the determinant it is.

Other than harmful air quality that leads to an increased risk of pulmonary disease, increased small particulate matter, wildfires, and air stagnation (in this paper, the 3 of these variables are being grouped together due to their similarity in all causing air pollution) all increase the chance of one getting cardiovascular disease. Furthermore, Figure 5 shows a correlation between specifically Eastern Washington's wildfire smoke prevalence and cardiovascular disease mortality. From a Health Impact Assessment of the 2020 Washington

State wildfire, there was 6.9% more cardiovascular deaths with each week of wildfire smoke exposure in the selected counties studied. This discrepancy shows that the prevalence of wildfire smoke in Washington's rural counties has a strong correlation to cardiovascular disease mortality. Additionally, air stagnation is prevalent throughout the state, and PM 2.5 concentrations are prevalent in Central and Eastern Washington, as are cardiovascular disease deaths (namely, the prevalence of cardiovascular disease mortality in Yakima County).

Furthermore, according to the EPA, increased exposure to PM 2.5 increases the risk for various cardiovascular diseases such as atherosclerosis. High PM 2.5 exposure can also cause cardiovascular mortality. Similarly, according to the NIH, PM 2.5 concentrations from wildfires increase risk of heart attack and cardiovascular death. Combined with the lack of infrastructure Washington's rural communities face, the increase in air pollution coming from various different factors negatively impacts cardiovascular health and puts rural individuals at risk for more cardiovascular diseases with less resources to control them.

Another environmental factor playing a role in increasing cardiovascular disease mortality in rural areas is an increased amount of lead exposure. Lead, a toxic, naturally-occurring metal, is incredibly awful for the human body to be exposed to. Until the 1970s, lead was used in everyday materials including house paint. Lead is still used today in vehicles and radiation shielding, but increased lead exposure has many negative impacts.

*Figure 8: Washington State Census Tract Map of Lead risk from housing from 2015-2019 (top) and Cardiovascular Disease Deaths per 100,000 from 2016-2020 (bottom).* 





*Figure 9: Washington State County Map of Childhood Lead Tests, Where the Darker Gray the County Is, the Less Tests Are Done.* 



In the above 2 graphs (Fig 8), lead exposure is higher in Washington's rural counties. Furthermore, there is also a correlation between lead risk from housing and cardiovascular disease mortality per 100,000, especially in Southeastern Washington. According to a systematic review of various NIH studies, there is a correlation between increased lead exposure and cardiovascular disease. More specifically, there is a causal relationship between lead exposure and hypotension, and there is a positive association between lead exposure and various cardiovascular diseases and strokes. Most often, the starting point in the decline of cardiovascular health is high blood pressure, which is closely related to lead exposure in the first place.

Additionally, Childhood Lead Tests, which are tests that are done with children using a blood sample, are low in more rural areas and areas where cardiovascular deaths are high (Fig 9). In this map as well, the darker the shading, the less lead tests are done. These correlations are incredibly vital in seeing that increased lead (and not identifying said lead) is related to the decline in rural cardiovascular. It is important to note, however, that the reasons why they are also correlated is also in part of the fact that clinics are more scarce in rural areas making it more difficult to get appointments. Nevertheless, the lack of lead testing, the high levels of lead exposure in rural areas, and healthcare facility "deserts" all play a role in worsening cardiovascular disease and cardiovascular disease mortality.

Overall, there are many economic and environmental factors working in tandem to make cardiovascular health in rural Washington worse. Altogether, the correlation between air stagnation, wildfire smoke, and lead exposure with cardiovascular disease mortality in Washington all give plausible reasons as to why cardiovascular disease is so much worse in rural communities. To add on top of this, the discrepancies rural communities face in terms of healthcare facility deserts, poverty, and less health insurance for adults between the ages of 19–64 make it harder for those in rural communities to tend to cardiovascular diseases they may

have, making them harder to control and increasing the cardiovascular disease mortality rate in these rural communities.

## Policy Proposal:

Using the information previously stated, there are several steps to be taken in order to make effective policy changes in order to fix this problem. Rural communities are disproportionately affected by cardiovascular disease while they also do not have nearly as many clinics as their urban counterparts. Furthermore, many more rural residents are in poverty and/or do not have health insurance (the most glaring disparity being Adams county with an uninsured rate of 27.8% while King county's uninsured rate is only 7.2%). Primarily, greater legislation on providing rural communities with up-to-date telehealth systems is a must in rural Washington. After the COVID-19 pandemic, telehealth has become increasingly popular, with more online therapy visits to even routine check-ups. Telehealth, in short, is the use of online communication to provide various different healthcare services online at the ease of one's home. Furthermore, telehealth is already encompassed in Washington Department of Health's Transformational Plan for healthcare in the state. Additionally, the DOH has various policy proposals suggesting workgroups and planning to increase quality in telehealth services to make them as successful as possible. To this proposal, it would be beneficial to add an emphasis on adapting to the variances that rural communities have to face in terms of healthcare (lack of local providers, healthcare facility deserts, etc.) as well as having them properly represented in telehealth workgroups including providers and community partners so that rural communities get not only their voice heard, but also the proper care without having to travel immense distances or leave their workplace. Representation may look like rural healthcare providers and even rural policymakers. legislators, and devoted residents. Considerations of rural communities may include researching internet access in rural communities and bettering internet access for communities who don't have that readily available. Another consideration would be multilingual care. Overall, telehealth will decrease visits to the physical doctor's office and will shift the emphasis on making the clinic a place for procedural duties. More specifically, for cardiovascular disease, bettering the telehealth system will help cardiovascular disease patients who don't have a cardiologist in their county (such as those in Adams, Franklin, or Grant counties) and may help them get more clarity in what is happening with them, as well as more frequent and informed updates on their health and when they may need to go into the clinic (physically). To add, telehealth treatments are a much more affordable option compared to an in person check up, where a patient would pay anywhere between \$40 and \$90 for a check-up without insurance. This is especially helpful for the rural communities with high uninsured rates, such as individuals in Adams or Franklin counties. In all, telehealth check-ups can act as a middle ground to determine next steps for patients who have compromised health, which can include involving providers that may not be medical doctors, such as Physician Assistants and Nurse Practitioners.

To address lead exposure, it would be worth making lead tests more available for people of all ages. Making lead tests more readily available/a more known option for parents to give to their children. Not only will they gain knowledge about their child, but they will also gain knowledge for themselves. One way this could be done is by having the DOH mandate (or highly recommend) lead tests for children, similar to how certain vaccines (such as Meningitis B or TDap) are administered. Of course, people would be able to exempt themselves from such testing, but mandating/highly recommending lead tests will bring more awareness to this crucial testing which (as said earlier) will give parents information on how they can help their children as well as help them take further steps in preventing lead poisoning (i.e. checking homes, etc.). To connect to telehealth, online appointments would act as a "precursor" to going in for a Lead Test.

Finally, to further address healthcare facility deserts and high levels of PM 2.5 concentrations, legislation should be made/passed where the Department of Health and Department of Transportation should work with one another to make public transit more widely available throughout the state, and not simply in urban cities through joint funding. Currently, multiple cities in Washington do FREE intercity transit, one of them being the state's capitol, Olympia. Sadly, public transportation is rarely used in any rural area (Fig 10).

Figure 10: Washington State Census Tract Map of Limited Public Transit to Work



Currently, 94.20% of working residents in Washington State do not use public transit, like buses. This is for multiple reasons, such as infrastructure not being up to par, especially in rural areas. It is additionally good to note that the majority of public transit is used in urban Washington along the Puget Sound. However, there are multiple reasons why increasing funding to public transit in rural areas would be beneficial for helping decrease cardiovascular disease mortality rates in rural Washington. Namely, it does **2** things: Firstly, it provides those who don't have a stable source of transportation to get transportation to their nearest healthcare facility or clinic. Secondly, furthering public transit infrastructure and PROMOTING it in rural communities is an incredible way to reduce air pollution and PM 2.5 concentration. It helps

reduce air stagnation and will not add to wildfire smoke due to less carbon emissions from gas vehicles, which will help atherosclerosis rates and reduce cardiovascular mortality rates.

Overall, these 3 policy changes in Washington will improve cardiovascular disease mortality rates in rural areas, and improve rural health overall. It is important we focus on rural communities, especially because of the lack of attention they get in modern media, research, and more.

#### Cardiovascular Rural Health and Equity:

As mentioned, rural health has been previously overlooked in many ways. From not being able to obtain nutritious meals to not getting proper medical care within 30 miles of where a patient lives, rural communities have to face difficult circumstances in their everyday lives to simply get the resources they need to live a healthy life. Furthermore, rural communities in Washington State additionally disproportionately have higher poverty rates and lower insurance rates compared to urban areas, making it very hard for these communities to get out of a generational cycle of poor infrastructure and lacking resources. With lacking resources come poor health outcomes, which this project is trying to diminish.

In the U.S. as a whole, rural residents on average live 10.5 miles from their nearest healthcare facility, while their urban counterparts only live on average 4.4 miles away from their nearest healthcare facility. While this doesn't seem like too much, rural residents have to travel over double the distance to be able to get the same (if not worse due to the lack of resources) care. To add, cardiovascular health in particular is affected by this because of not only Primary Care Providers, but specialists as well. When even PCPs are scarce in rural areas, interventional cardiologists would seemingly be even harder to find. In the U.S. in total, those living in rural areas are 19% more likely to get heart disease than their urban counterparts. Moreover, rural Black male residents are the most disproportionately affected by this, with their risk being 34% higher than their urban counterparts, according to an NIH study. Through systematic racism, generational cycles, and lack of resources to better adverse effects, rural communities and rural communities of color have been ignored and mistreated by the medical system through mistrust and lack of funding.

With this project, it is seeking to help the most vulnerable rural communities to obtain more resources through various different pathways, even if they may not be traditional.

This proposal seeks to help Washington rural communities' problems by addressing the main issues that stop them from accessing proper healthcare that would help cardiovascular disease rates. These main issues include: healthcare facility deserts, lack of transportation infrastructure, and lack of resources to help certain (unavoidable) environmental issues. By making various forms of healthcare appointments available to rural patients by bettering telehealth databases and making the internet more standardized/widespread, patients no longer will have to frequently travel to another county to obtain a visit with a specialist provider, such as an interventional cardiologist. It additionally addresses the fact that rural communities are

disproportionately affected by poverty and low health insurance rates because telehealth appointments are typically much more affordable than standard in person visits. By bringing awareness to and mandating/highly recommending lead tests, rural residents can be educated on the importance of lead tests and how detrimental lead is to cardiovascular health and hypertension in particular. Oftentimes, rural communities are hit with a lack of education, so education on lead tests will help parents educate themselves and their children about the consequences of lead. Finally, the standardization of public transit throughout the state, specifically for rural residents to get to a healthcare facility without having to have a car. This addresses socioeconomic disparities faced by rural Washington residents. Furthermore, it addresses the increasing PM 2.5 concentration in rural areas because of less use of gas emitting vehicles. Altogether, all of these solutions help rural communities in Washington that are disproportionately affected by the lack of medical resources, and help those with a lower socioeconomic status and marginalized communities within Washington's rural communities.

#### Health Impact:

This project will have various positive health impacts because it not only positively impacts cardiovascular health, but other health outcomes as well. Increased education through greater access to medical procedures (such as lead testing) allows rural residents to be informed on all possible cautions around them. This helps rural communities be more careful and even encourage them to do more research and be able to take more action towards changing negative outcomes (such as increased lead exposure). Additionally, greater education in rural communities empowers rural residents to make educated decisions and choices which allow them to take control of their health and their future, effectively breaking generational cycles of poor health outcomes. By breaking poor health outcome cycles, rural residents have the ability to not only take greater control of their lives, but also give themselves enough time to leave unfortunate situations they may have been placed in. Furthermore, increased access to various healthcare appointment options takes away many of the pressures of rural patients who have had to travel far distances to get to medical appointments. This helps rural residents have doctor's appointments when they truly need them rather than pushing them off and harming their health indefinitely. More frequent doctor's appointments for those who especially are on track to having a cardiovascular disease is the difference between living for 15 more years or 5 more years. Appointments help catch cardiovascular diseases earlier on, which can also help rural residents take further control of their diseases and live a normal daily life in which they can live without having to stress about additional medical expenses their disease may have caused them. Furthermore, increased doctor's appointments give patients more education about their health, which not only empowers them to make the correct medical decisions for themselves, but also helps them educate future generations to come, breaking cycles of lacking medical education. Finally, increased public transport fosters connectivity between communities, and makes travel much easier. Additionally, the use of public transportation will accelerate the shift to fully

electric public transportation vehicles all throughout the state (cities such as Seattle have implemented this already). This will reduce PM 2.5 concentration even further, bettering cardiovascular health in the process. The use of public transport will also encourage greater walking (to bus stops, etc.) rather than driving and parking right next to the location of service.

## Reflection:

Throughout this project, I have learned a lot about various nuances in rural health that I didn't know before. I have always been interested in rural health and cardiovascular health, so going into this project, I was excited to combine the two subjects. Before starting this paper, I had previously known about various ethnicities' predispositions to cardiovascular disease. For example, South Asians are often credited to being predisposed for greater risk of cardiovascular disease, as are Black people and Latinos. In Washington State, Representative Pramila Jayapal even sponsored the South Asian Heart Health Awareness Act which seeked federal funding towards research to explore more about South Asian heart health. When looking at WTN maps, however, I noticed something incredibly interesting in rural communities. For many of the characteristics, rural communities in Washington State were predominantly characterized by having less resources, worse health outcomes, and less education overall.

Rural communities having fewer opportunities than urban communities was, coincidentally, something I had also kept an eye on through policy research and discovery throughout the year. For example, Congress in the past has passed bills that used Medicaid funding to increase residency slots in rural areas so more doctors could be trained in rural areas and rural residents would have more providers to care for them. Along with this, through the Information by Location Tracker through the Washington Tracking Network, the Cardiovascular Mortality Rate per 100,000 overlaid with all of the clinics in Washington showed that where cardiovascular mortality was high, the amount of clinics in the area were low. All of these factors propelled me into research about Cardiovascular Health in Rural Washington! It was really interesting to combine 2 separate things I was interested in into 1 project and I was able to learn a lot from it.

As for my approach towards this project, I looked through dozens upon dozens of different topics, subtopics, and measures to look for any more associations and correlations. I was able to find a couple of them, but it was really difficult to find direct associations between various topics and subtopics. I also made a point to use the census tract maps for almost all of the maps because census tracts represent the communities in Washington much more precisely than counties. After looking through the maps, I decided to research more on what made cardiovascular health worse, why rural communities had poorer health outcomes, and how rural cardiovascular health suffered tremendously. After doing this research, I had a guide of what to look at on the maps and charts, which made it much easier to pinpoint correlations throughout the data. The main hardships I had (as I had mentioned previously) was figuring out where to go from seeing the correlation between cardiovascular mortality and rural areas. More specifically,

it was difficult to start to see the reasons why cardiovascular mortality happened more often in rural areas. Furthermore, I made a couple of my own charts and graphs using Google Sheets and the WTN Tracking Data, which was incredibly difficult to do with the census tracts due to the sheer number of census tracts there were. Another major challenge I faced was trying to put this paper together in a cohesive manner that had its main focus in Washington and its various communities, while also using data from other sources including the entire U.S. population and not generalizing rural communities too much. I gave specific examples and stats using WTN data as much as I could throughout this paper. Finally, the last major challenge I had was choosing what sort of policy reforms I could implement to solve this problem to be feasible. I brainstormed many things, a lot of which were incredibly expensive. It was important to make sure that the policy proposal was as effective, yet inexpensive as possible. Looking at the economic state of Washington right now, (as we are on a somewhat extreme budget deficit) it is hard to look for policy proposals that could be as inexpensive as possible yet reap the maximum amount of benefits. In other words, the policy suggestions in this paper had to be worth spending the money on, which was an incredibly daunting task to figure out. In the end, I believe that I was able to do it, although passing legislation for this is a feat in itself. Thankfully, however, after speaking to multiple state senators and representatives in the past, much of what is proposed in the Washington State Legislature is bipartisan and passes; the policy proposals I have proposed in this paper are for the most part bipartisan as well.

Finally, I couldn't have done this paper without the extensive support I have gotten. I am incredibly thankful for all of the help I've gotten throughout writing this paper and I am immensely thankful. My biggest help were my parents in giving me advice on how to write this paper and ideas for what I could add/subtract, and Dr. Ranjini Krishnan, a close family friend, who is a Cardiologist working at Olympic Medical Center in Sequim. She not only works in a rural area, but has done cardiovascular research. Her experience in this field helped me immensely in this topic and she helped guide me through what various topics or subtopics I should explore and how to go about looking at my data as well as editing the paper. I am so thankful for all of the help I have received doing this project and I wouldn't have been able to complete this feat without the guidance of several mentors. They all, like myself, care deeply about rural cardiovascular health.

Finally, throughout this paper, I did not use artificial intelligence as my main source of information. If automated artificial intelligence databases were on platforms (such as Google's Gemini, for example), I would click on the article link where the AI platform got the information from, or scroll down until I found that article link. I did **not** use any of the direct answers that Google's automated AI gave to me and instead used answers from websites; therefore I did not use AI. It was not used for creating any pieces of information, writing, pictures, data visualizations, etc nor was it used for brainstorming or additional resources. As for grammar, I used Google Docs grammar suggestions and proofreading. I did not use any separate platforms such as ChatGPT, OpenAI, QuillBot, or anything else. All of the work on this research paper is my own.

In all, the rural cardiovascular health problem in Washington State is an issue that needs to be addressed. Through advocacy of various policy proposals with you, me, and the rest of Washington State, we will be able to better outcomes for our rural neighbors. It is important to note that change doesn't merely happen through bystanding. Change is action.

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