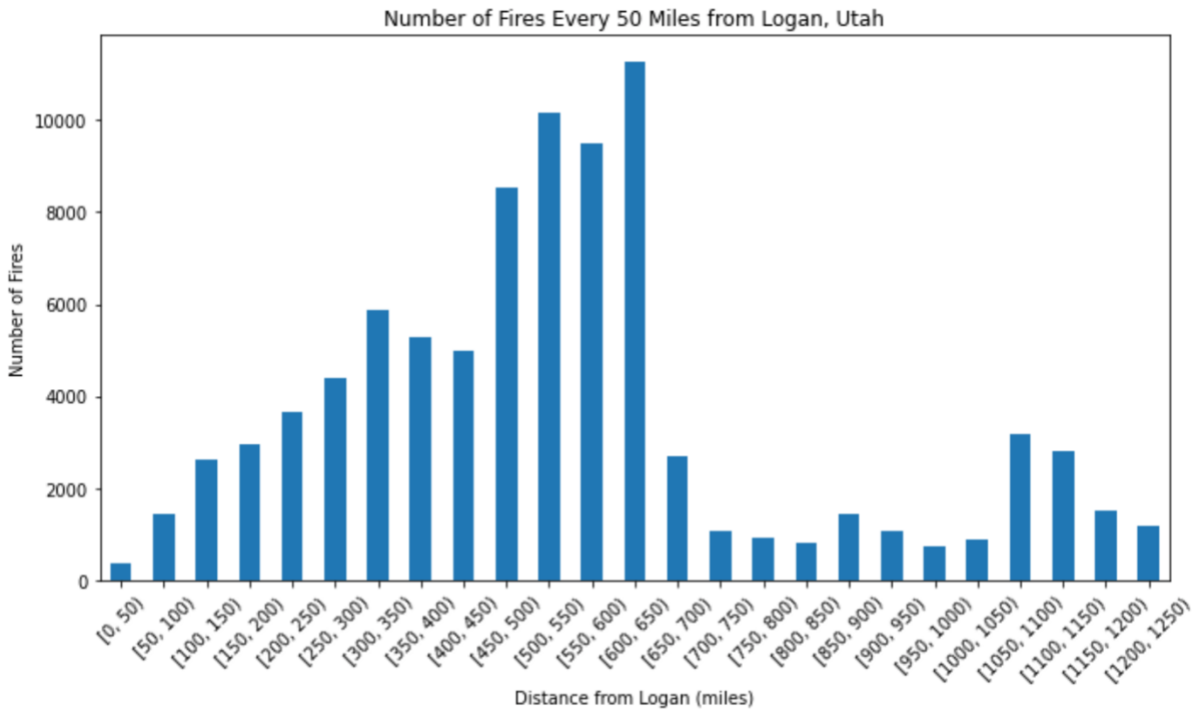
More and more frequently summers in the western US have been characterized by wildfires with smoke billowing across multiple western states. There are many proposed causes for this: climate change, US Forestry policy, growing awareness, just to name a few. Regardless of the cause, the impact of wildland fires is widespread. There is a growing body of work pointing to the negative impacts of smoke on health, tourism, property, and other aspects of society. The course project will require that you analyze wildfire impacts on a specific city in the US. The end goal is to be able to inform policy makers, city managers, city councils, or other civic institutions, to make an informed plan for how they could or whether they should make plans to mitigate future impacts from wildfires.

This investigation into the potential smoke impacts on Logan Utah begins with the common analysis portion. Here we see some general trends surrounding wildfires around Logan Utah.

Common Analysis Part 1, Visualization Explanations and Reflection

Visualization 1: Produce a histogram showing the number of fires occurring every 50 mile distance from your assigned city up to the max specified distance.

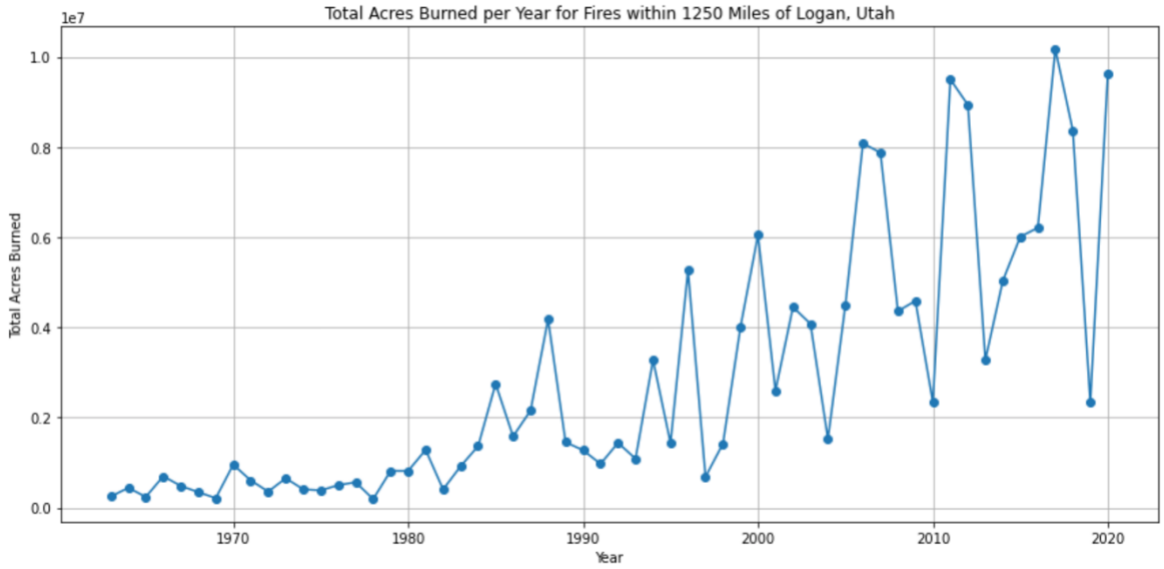


The x-axis of the bar chart represents the distance from Logan in miles, ranging from 50 to 1250 in increments of 50 miles. The y-axis represents the number of wildfires that occurred within each distance range. The best way to read this figure is to look at the x axis to get an idea of the

ranges and then look at the y axis to see how many fires fit into each of those buckets. Each row in my dataset represents a fire and each fire has a specific distance from Logan, Utah. This distance was calculated between the coordinates of the city and the coordinate point within the fire polygon which is closest to the city. Only the fires with a distance less than or equal to 1250 miles were included in the final dataset. It is also important to note that before the 1990's, there was significantly less data available on wildfires and diligent documentation was not as prevalent. There could be some bias in the data if the nature of the landscape was different before 1990. This bias would skew the distribution of fires we see in the histogram.

We can see clearly that the bulk of wildfires that are within 1250 miles are within 650 miles of the city. There is also a range of wildfires that occur between 650 and 950 miles from Logan, with a slight decrease in frequency beyond 950 miles. It picks up again past 1000 miles and drops after 1100. This suggests that the proximity to forests, grasslands, and other fire-prone areas plays a significant role in the occurrence of wildfires near Logan.

Visualization 2: Produce a time series graph of total acres burned per year for the fires occurring in the specified distance from your city.

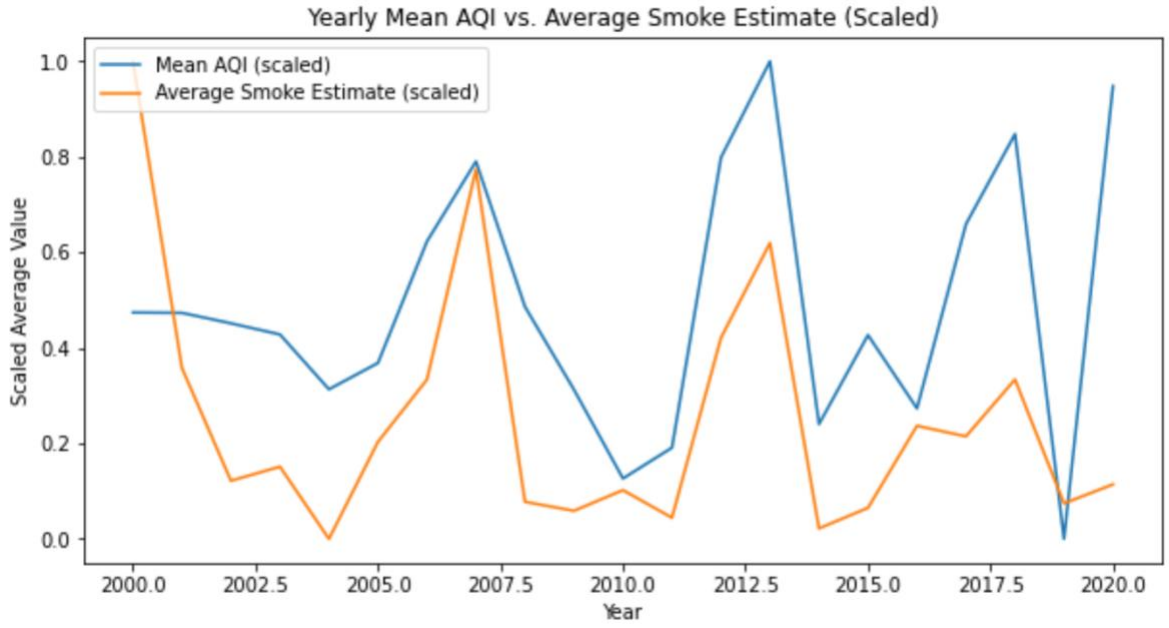


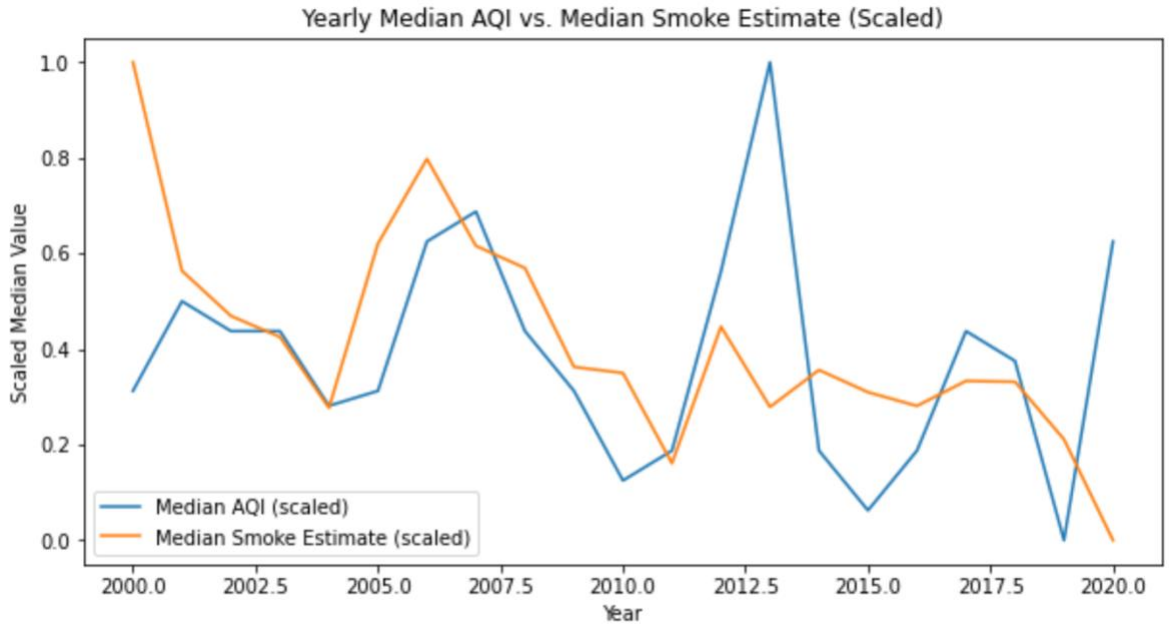
My graph depicts the total acres burned due to wildfires within 1250 miles of Logan, Utah, from 1970 to 2020. The visualization employs a line graph to showcase the trend of total acres burned over time. The x-axis represents the year, ranging from 1963 to 2020, while the y-axis represents the total acres burned in each year, with a maximum value of approximately 10,000 acres. The

calculations behind this visualization were straightforward, our given dataset (the USGS Combined wildland fire dataset) contained a feature called GIS Acres that provided us the acreage of the fire; we only included fires that were within 1250 miles of Logan, Utah. This distance was calculated between the coordinates of the city and the coordinate point within the fire polygon which is closest to the city.

The line graph clearly demonstrates a significant increase in the total acres burned due to wildfires over the years. In 1970, only around 2000 acres were burned. However, the trend steadily increased throughout the 1980s and 1990s, reaching a peak of nearly 10,000,000 acres in 2020. This suggests that the frequency and intensity of wildfires in the region surrounding Logan have been on the rise.

Visualization 3: Plot 3: Produce a time series graph containing your fire smoke estimate for your city and the AQI estimate for your city.





My graphs showcase the relationship between the average AQI (Air Quality Index) and the average smoke estimate for the years 2000 to 2020. The visualization employs a line graph to display the trends for both metrics over time. The reason that is starts at 2000 is because that is when the estimates became available from the EPA for my specific city.

We also have to make that we are clear on the units. The Air Quality Index (AQI) is a dimensionless index created by the Environmental Protection Agency (EPA) to communicate how polluted the air currently is or how polluted it is forecast to become. It's a scale that runs from 0 to 500, where the higher the AQI value, the greater the level of air pollution and the

greater the health concern. An AQI value of 50 or below represents good air quality, while an AQI value over 300 represents hazardous air quality.

For PM2.5 (particulate matter less than 2.5 micrometers in diameter), which is often a major component of smoke from wildfires, the AQI is based on the concentration of PM2.5 particles in the air over a 24-hour period and is typically measured in micrograms per cubic meter ($\mu g/m^3$).

The x-axis represents the year, ranging from 2000 to 2020. The y-axes represent the average AQI in either median or mean. Both axis have been scaled because their original scales were vastly different and it would be difficult to make a comparison on the same plot. The effect of this scaling is to translate each feature individually such that it is in the given range on the training set, which is typically between zero and one. This has the benefit of bringing different features into a common scale while maintaining relationships in the data.

Let us discuss how we calculated the values. Starting with smoke estimates. The smoke impact score that I calculated is based on the size of the fire and its distance from a specific location, following the inverse square law of dispersion. This law suggests that the intensity of an effect such as smoke diminishes with the square of the distance from the source.

Here is the formula for the smoke impact score:

$$\text{Smoke Impact Score} = \frac{\text{Size of Fire}}{(\text{Distance from the City})^2}$$

In this formula:

- "Size of Fire" could be represented by the number of acres burned.
- "Distance from the City" is the distance between the fire's location and the city in question (in this case, Logan, Utah).

By applying this formula to each fire event, you can estimate the smoke impact on the city. The smoke impact score is higher for larger fires and those closer to the city, and it decreases as the distance increases. This score helps in understanding and estimating the potential smoke exposure to the city from various fires.

Every fire had one of these scores and I just simply took the mean and median of all of the fires for a given year.

Now let’s discuss the AQI score. When calling the API, this is the logic I used when deciding on which sensors to focus on:

The code is designed to retrieve daily summary data for particulate matter with a diameter of 2.5 micrometers or smaller, commonly referred to as PM2.5. The 'param' parameter in the API call is set to '88101', which is the code for PM2.5 in the EPA AQS database. PM2.5 is a significant pollutant often used as an indicator of air quality because these fine particles can penetrate deep into the lungs and even into the bloodstream, causing health issues. The concentration of PM2.5 is particularly relevant when estimating smoke impacts from wildfires, as these particles are a major component of wildfire smoke.

When looking at the two graphs, we can see how they follow each other pretty well until they reach 2012 and then it diverges more. This suggests that my smoke estimate and the AQI score are moderately similar in measuring the smoke impacts from wildfire.

There are certain topics that are important to most people. These include things like natural disasters, widespread health epidemics, financial collapse etc. These sets of topics can be categorized as either pertaining to one's physical health or to one's financial health. Wildfires are a natural disaster that can impact both of those important considerations. We will focus our analysis on the city of Logan, Utah in Cache County. It is a region that experiences Wildfires, understanding the impact of these events is of paramount importance. The goal of this analysis is to delve into the multifaceted effects of wildfires on the community, encompassing both the physical health of residents and the economic wellbeing of the area. By doing so, the study aims to provide actionable insights that could guide both policy and individual decisions to mitigate these impacts.

From a scientific perspective, this analysis presents an opportunity to explore the interplay between natural disasters and human communities in a changing climate. Wildfires, exacerbated by climate change, present an increasing threat to areas like Logan. This analysis could contribute to a broader understanding of how such communities can adapt and respond to these challenges. Furthermore, studying the specific impacts on Logan can shed light on similar communities facing wildfire risks, potentially offering a template for research and action in other regions.

On a practical level, this analysis is intended to inform local authorities, emergency services, and community groups in Logan about the specific risks and consequences of wildfires. By understanding how wildfires affect various aspects of life - from air quality and public health to local economies and housing markets - stakeholders can develop more effective strategies for preparedness, response, and recovery. This could include enhancing emergency response protocols, improving communication systems during wildfires, or developing economic support mechanisms for affected businesses and individuals. The types of mitigation efforts that might be needed on a city-wide level require incredibly high funding and sophisticated planning. The earlier that we can forecast increasing issues, the more likely we are to minimize the damage.

Ultimately, this study hopes to learn how wildfires impact Logan, Utah, and to use this knowledge to empower the community. By providing a comprehensive overview of the consequences of wildfires, the study aims to foster a more resilient community, better equipped to handle future disasters. The findings could also advocate for more robust policy measures at

the local and state level, emphasizing the need for proactive wildfire management and community safety initiatives. This is the goal, and I will try my best to provide useful insights.

The first thing that we need to do is define the scope of the analysis. There are several different areas where I can focus and they are all interesting in their own way. Healthcare can be a great focus because it addresses hospitalizations, diseases, sicknesses, or death. All of these are top concerns for the average citizen. Many problems become insignificant when one is on the verge of death or very ill. In the order of what people value, the next more important consideration is economics. After health, a place to live and have your basic needs met is second place. This takes money and is also related to your health directly. Especially in the Unites States, healthcare is not a guarantee to everyone and even insured people can have very large out of pocket bills.

Economics is a critical area of focus in understanding the impact of wildfires. In Logan, where certain industries might be predominant, wildfires can significantly disrupt production processes. This disruption can lead to worker absences due to health concerns or evacuation orders, resulting in lost productivity and sales. The financial ripple effect of such events can be extensive, affecting not just the primary industries but also the secondary businesses that rely on them. Analyzing these economic impacts provides crucial insights into the overall resilience of the city's economy in the face of wildfires. It also helps in identifying sectors most vulnerable to such disruptions, enabling targeted support and planning for future incidents.

The service industry, including restaurants, lodging, and tourism-related services, can be another important area to explore. Wildfires can drastically reduce the influx of tourists, a key source of revenue for many local businesses. This reduction not only impacts businesses directly linked to tourism, such as hotels and tour operators, but also has a cascading effect on the broader service sector, including retail and food services. Understanding these impacts can guide strategies to support these businesses during and after wildfire events. Additionally, analyzing how wildfires affect the availability and quality of services, like healthcare and transportation, can inform improvements in emergency preparedness and response.

Next, education was a consideration because it can get very important when you start to look into it more carefully. Wildfires can lead to school closures, affecting student learning outcomes. The concept of "smoke days," similar to "snow days," where schools close due to poor air quality or fire threats, raises questions about the continuity of education during such crises. Investigating the frequency of these closures, their duration, and their impact on both students and educators can provide valuable insights. This can lead to the development of strategies to ensure educational continuity, such as remote learning solutions during periods of disruption. After the Covid-19 pandemic, schools have become more accustomed to learning from home. This change may reduce the impact of having smoke days.

And, my last (but not least) consideration was examining community differences. Different demographics within Logan may experience these events differently. For instance, the unhoused population or those in more vulnerable housing situations may face greater risks during wildfires. Similarly, certain neighborhoods might be more exposed to fire hazards or have

less access to emergency resources. Analyzing these disparities is crucial for developing inclusive and equitable disaster response strategies that cater to the needs of all community members, regardless of their socioeconomic status.

So how did I decide on which area to focus on? Being no stranger to this type of analysis, I knew finding a good dataset or model was going to be the difficult bit. After spending some time with broad searches, I concluded that it would be best to focus on either economic or healthcare data. These were really the only type of datasets I could even begin to find for the state of Utah. This was not considering that I needed more specific data for Logan and even more specific data for healthcare or economics. Honestly, I was not able to find too much out there. I found a model called the CLIMADA model which focused more on damage to properties and infrastructure vs. the economic impacts of the smoke. I also tried to find datasets on national and state parks next to Logan. That area attracts over 1 million visitors a year who are looking to admire the local nature and scenery. It would make sense that smoke detracts at least some percentage of the visitors and will therefore have a negative economic impact on Logan. It is the nearest large city to these attractions. However, I could not find such a dataset. Another idea I had was to use google trend searches for the names of the parks. The idea was to use it as a proxy or indicator of attendance to the parks. That data proved to be only recent and is based on many assumptions. It may be too much of a stretch for me to link google searches for a certain park to visitors to a nearby city and then to an economic impact.

Eventually I came across a tool developed by the Utah Department of Health (https://epht.health.utah.gov/epht-view/query/selection/hddb/HDDBSelection.html). The data is freely available for non-commercial use, but redistribution requires authorization from the Utah Department of Health. This tool allows me to grab hospital data by year and also do some other filtering for specific types of hospitalizations like respiratory issues or eye issues. The general idea is that I want to predict the increased strain on the healthcare system due to the projected increase in smoke. The data should show me the rate at which hospitalizations have been increasing. However, drawing a relationship between hospitalizations and increase in smoke will not be easy and many assumptions will have to be implemented. One initial concern is if the historical data does not seem to have any relationship with the different intensities of the Wildfire seasons. Since there is not a ton of data, I assume that seeing these relationships will be difficult. Perhaps I can add some factor to the increasing rate of hospitalizations in order to account for the increasing smoke factors. Or perhaps I can make a case that the increased hospitalizations could in some part be due to the increasing smoke over a longer period of time. It is plausible that a generation of people who grew up over a thirty-year period with increasing average smoke will only see the negative impacts the increased smoke much later in their lives.

My plan is to use the dataset to find hospitalization records as specific to Logan, Utah as possible and to try to understand the general trend. I will then try to understand how I could potentially attribute a part of that increase to Wildfires or how I can take the projected rate and modify it based on the smoke estimate. Here is a study that discusses a potential pathway to

quantify the effects of Wildfires on respiratory health (https://www.nature.com/articles/s41467-021-21708-0).

In considering the unknowns and dependencies that might influence the scope of this analysis, it's crucial to acknowledge the factors that are beyond my control, which could impact the ability to answer the supplementary research questions within the allotted time.

First and foremost, the availability and detail of data are significant variables. The Utah Department of Health's hospital data, while a valuable asset, may not offer the granularity needed to precisely correlate hospitalizations in Logan with wildfire smoke. This potential gap in data specificity could limit the depth of my analysis and the robustness of the conclusions I can draw.

Furthermore, the historical and predictive data regarding wildfire intensity and frequency in the Logan area are essential. Historical data, while accessible, presents only part of the picture. Predicting future trends, a crucial element of this study, relies on complex models. These models, influenced by a range of unpredictable variables such as climate patterns, can be difficult to navigate and are not entirely within my control. This adds a layer of uncertainty to the forecast of future wildfire impacts.

Another critical aspect is the methodology required to link increased smoke exposure to long-term health outcomes. The research pathway suggested in the Nature article offers valuable insights, yet applying these findings to Logan's specific context involves making assumptions that may not hold true in all cases. This presents a risk of over or underestimating the actual health impacts, a factor that must be carefully balanced in the analysis.

The economic and social impacts of wildfires, encompassing local industries, tourism, and education, are influenced by a myriad of external factors. These include policy decisions, economic trends, and societal reactions to wildfire and smoke exposure. Any shifts in these areas could substantially alter the landscape of my analysis, adding another layer of complexity to an already intricate subject.

Lastly, the time constraint is an ever-present consideration. To conduct a comprehensive and accurate analysis within a limited timeframe is to walk a tightrope between breadth and depth. This balancing act, while challenging, is crucial to maintain the integrity and utility of the study.

The intricate relationship between wildfire smoke and health care demands in Logan, Utah, presents a unique challenge. With the predicted 26% increase in smoke over the next decade, as indicated by the linear model, it's imperative to understand the potential strain on our healthcare system. While the increase in respiratory illness-related admissions to the Emergency Department appears small, it's crucial to consider the broader implications of prolonged smoke exposure on public health.

To delve deeper into this matter, a comprehensive approach is required, one that considers not only immediate health concerns like respiratory illnesses but also long-term effects. Chronic exposure to particulate matter in wildfire smoke could lead to a gradual increase in cardiovascular and respiratory conditions, which may not be immediately apparent in emergency room data.

The complexity of healthcare in the United States, especially in terms of costs and access, further complicates the scenario. An uptick in health issues related to smoke could exacerbate existing inequalities in healthcare access, disproportionately affecting the most vulnerable populations in Logan. This necessitates a strategy that is both preventive and inclusive.
Moreover, the indirect effects of wildfire smoke, such as stress and anxiety caused by persistent poor air quality, need to be factored into the healthcare equation. Mental health, often a secondary consideration in environmental health crises, can significantly impact the overall well-being of the community.

In terms of preparedness, the healthcare system in Logan must be equipped not only with the necessary resources but also with strategies to handle potential increases in patient volume. This includes training healthcare professionals to recognize and treat smoke-related ailments effectively and ensuring that facilities are adequately staffed and supplied.
Public health communication plays a crucial role in mitigating these health risks. Regular updates about air quality and health advisories, along with guidelines on how to minimize smoke exposure, can help the community take proactive measures to protect their health.
Another aspect to consider is the impact on healthcare workers themselves. Prolonged periods of poor air quality could affect the health and performance of those on the front lines, necessitating measures to safeguard their well-being while they care for others.
Longitudinal studies are essential to comprehensively understand the health impacts of wildfire smoke. Such studies could provide valuable insights into the correlation between smoke exposure and various health conditions, helping to inform future healthcare strategies and policies.

Collaboration with environmental and public health experts will be crucial in this endeavor. By integrating data on air quality, wildfire trends, and health outcomes, a more holistic understanding of the situation can be developed. This multidisciplinary approach is key to addressing the multifaceted nature of this challenge.
In conclusion, while the direct impact on emergency department admissions in Logan may currently seem minimal, the potential long-term health implications of increasing wildfire smoke cannot be overlooked. Proactive planning, resource allocation, and community engagement are imperative to ensure the health and well-being of Logan's residents in the face of this growing environmental concern.

The predictive models used in our analysis, although helpful, have their limitations. They provide an estimate of future conditions based on current trends, but they cannot account for all variables that might influence wildfire smoke and its impact on health. This uncertainty necessitates a flexible and adaptive approach in healthcare planning and response.

Considering the potential increase in healthcare demands, it's vital to explore funding options for expanding healthcare services in Logan. This could include government grants, partnerships with private organizations, and community fundraising efforts. Such financial support would be essential in enhancing the capacity of local hospitals and clinics to deal with an influx of patients suffering from smoke-related health issues.

Community engagement is another critical aspect of this endeavor. Educating the public about the health risks of wildfire smoke, and ways to mitigate these risks, can lead to better health outcomes. Workshops, school programs, and community meetings could be effective platforms for this education.

Moreover, the role of technology in monitoring and managing health risks should not be underestimated. Investment in air quality monitoring systems and the development of mobile

applications that provide real-time air quality data and health advice could be instrumental in helping residents make informed decisions about their exposure to smoke. Furthermore, the integration of mental health services into the response to wildfire smoke exposure is paramount. Counseling services, support groups, and mental health hotlines could provide much-needed support to those experiencing anxiety or stress due to poor air quality.

The healthcare system in Logan also needs to be prepared for the possibility of evacuations during severe wildfires. This includes having evacuation plans in place and ensuring that medical supplies and equipment are readily transportable. Additionally, collaboration with neighboring cities and states could be beneficial. Sharing resources, information, and best practices can enhance the region's overall capacity to respond to the health impacts of wildfire smoke. In advancing our understanding of the health impacts of wildfire smoke, research should not only focus on physical health but also consider the socioeconomic factors that influence health outcomes. This includes studying the impact on different demographic groups, with a focus on identifying and addressing disparities in health impacts and access to care. Ultimately, the challenge of addressing the health impacts of wildfire smoke in Logan is multifaceted and requires a coordinated effort from various stakeholders. By adopting a proactive and comprehensive approach, Logan can better protect and promote the health of its residents in the face of increasing wildfire smoke.