Estimating the Impact of Smoke from Wildfire Exposure on Respiratory Mortality in Gresham, Oregon (OR)

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Introduction

Over the years, wildfires have become a growing concern for many regions across the United States. In Gresham, Oregon, the threat is particularly pressing. Events like the 2017 Eagle Creek Fire burned nearly 50,000 acres and forced evacuations across Multnomah County, and the 2020 Labor Day windstorm covered the region in smoke which "led to the worst air quality in the world for several days"[1], highlighting the growing severity of wildfire impacts in the region. Figure 1 illustrates that Gresham is surrounded by areas of moderate to high wildfire risk, underscoring the need for localized strategies to address the growing hazards of wildfire events. These events disrupt local economies, strain public health systems, and disproportionately affect vulnerable populations. As wildfire smoke worsens air quality, targeted analysis and intervention of its health impacts has become more urgent than ever.

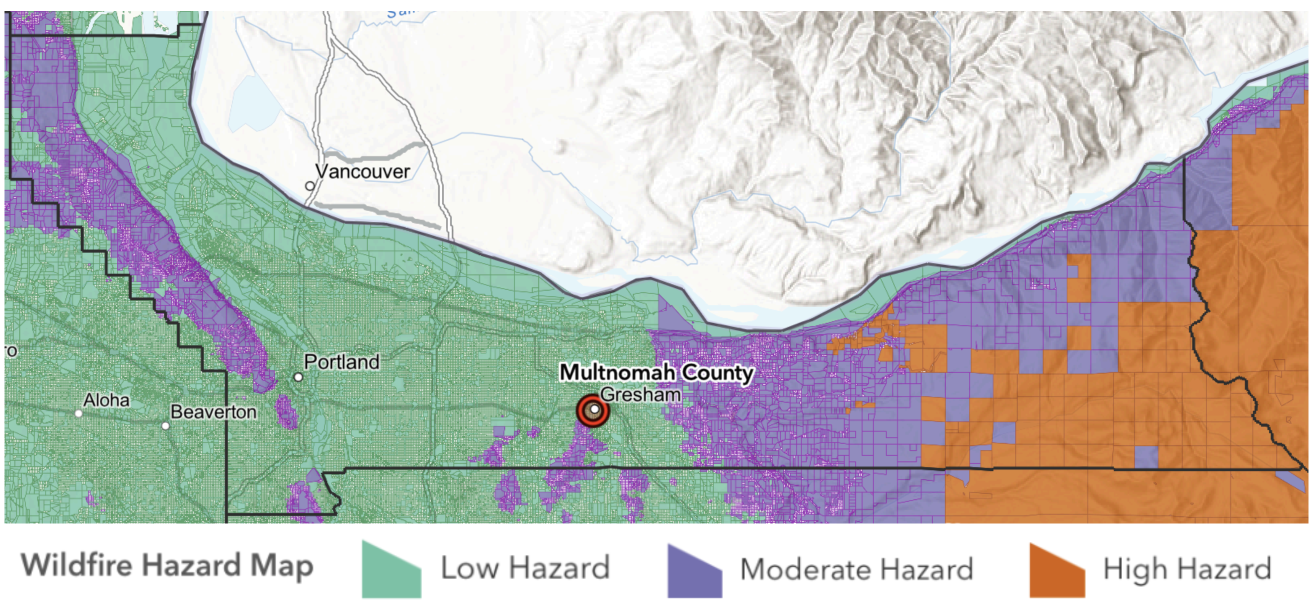

Figure 1. Wildfire Hazard Map of Multnomah County

The figure shows Multonomah county and its surrounding area from the [Oregon WIldfire Risk Explorer](). The figure highlights that Gresham has areas of moderate and high wildfire risk. The red circle represents Gresham, OR.

While wildfire smoke's emission of fine particulate matter, such as PM2.5 and PM10[2], both of which have severe implications for human health, this report will investigate its impact on respiratory mortality. PM2.5 particles are especially harmful because they penetrate deep into the lungs and enter the bloodstream, exacerbating conditions like asthma, chronic obstructive pulmonary disease (COPD), and other respiratory illnesses. PM10, while less penetrative, also significantly irritates the respiratory system, compounding health risks for individuals with pre-existing conditions. Both pollutants are associated with increased emergency room visits, hospitalizations, and mortality rates[3].

Gresham's population of approximately 110,000 includes many vulnerable groups, such as children, older adults, and individuals with pre-existing respiratory conditions. These populations face heightened risks from wildfire smoke exposure, particularly due to the health effects of PM2.5. Among the many health impacts, this analysis focuses specifically on respiratory mortality, a critical and measurable consequence of prolonged exposure to fine particulate matter.

This project aims to investigate the relationship between wildfire smoke and respiratory mortality in Gresham, Oregon. By analyzing historical wildfire and health data, it seeks to quantify trends, forecast future impacts, and provide actionable insights to guide public health strategies and policy recommendations. This work addresses a pressing public health challenge and contributes to ongoing efforts to mitigate the adverse effects of wildfire smoke exposure on vulnerable populations.

Background and Related Work

Wildfire smoke has been extensively studied for its effects on public health, particularly its association with respiratory illnesses and mortality. Previous research by organizations like the CDC and WHO highlights that fine particulate matter (PM2.5) in smoke exacerbates chronic respiratory diseases such as COPD, asthma, and interstitial lung disease[3,4]. PM2.5, smaller than 2.5 microns in diameter, is small enough to penetrate deep into the lungs and enter the bloodstream, making it particularly hazardous. Coarse particulate matter (PM10), though larger at up to 10 microns in diameter, can also irritate the respiratory system and worsen pre-existing conditions, especially for those with compromised lung function[5,6]. Both pollutants are major byproducts of wildfires and are strongly linked to increased emergency room visits, hospitalizations, and respiratory-related deaths[7].

Existing Forecasting Models and Applications

Forecasting models for wildfire smoke and its health impacts are still evolving, and there is limited research that specifically focuses on Gresham, Oregon. However, several relevant tools and studies provide a foundation for this type of analysis:

- **AirNow and HYSPLIT Models**: Tools like AirNow and NOAA's HYSPLIT model provide real-time and forecasted air quality data, tracking the dispersion of PM2.5 from wildfires. While these models are widely used to monitor smoke dispersion, they focus on short-term forecasting rather than long-term historical trend analysis for specific cities like Gresham[8,9].
- **Regional Air Quality Studies**: Studies in the Pacific Northwest have quantified the regional health impacts of wildfire smoke, but these are often generalized and lack granularity at the city level. For example, the Oregon Health Authority has examined trends in asthma-related emergency visits during wildfire events, but without linking these directly to long-term mortality or localized forecasting[10,11].
- **Wildfire Emission Inventories**: Frameworks like the BlueSky Smoke Modeling Framework estimate wildfire emissions and smoke dispersion based on fire size, fuel type, and meteorological data[11]. However, these models do not directly link smoke exposure to health outcomes or provide city-specific long-term forecasts.
- **Time Series Models for Wildfire Smoke Forecasting**: Recent studies have utilized time-series forecasting models, such as ARIMA or Prophet, to predict future wildfire smoke exposure[12]. While these methods are effective for identifying trends, applications to health outcomes like respiratory mortality remain limited.

No prior research has directly applied forecasting models to estimate the future smoke impact of wildfires on Gresham, Oregon, or assessed its effects on respiratory mortality. This research seeks to fill that gap by integrating historical wildfire and health data into a predictive framework, combining methods for smoke impact estimation with forecasting models.

Research Questions and Hypotheses

This project focuses on two primary research questions:

1. **What is the future smoke impact of wildfires on Gresham, OR, based on historical data?**
    - **Hypothesis**: The smoke impact, as measured using the inverse square law, will show an increasing trend over the forecast period (2025–2050), reflecting the growing intensity and frequency of wildfires.
2. **How does this smoke impact affect respiratory mortality in Gresham?**

- **Hypothesis**: Increases in annual smoke impact will correlate with rising respiratory mortality rates, particularly for illnesses strongly associated with PM2.5 exposure, such as COPD and chronic respiratory diseases.

By addressing these questions, this study builds on existing research while providing a localized analysis and actionable insights specific to Gresham, Oregon. The integration of smoke impact estimation with long-term mortality forecasting aims to bridge the gap between environmental data analysis and public health outcomes, offering a novel approach to understanding and mitigating the risks of wildfire smoke.

Model Selection

Most existing models for analyzing wildfire smoke impact mentioned in the above section are not open source. To ensure transparency and accessibility in decision-making, I chose Prophet to forecast long-term mortality linked to smoke impact.

Prophet, a time-series forecasting model developed by Meta, was instead selected for its ability to handle seasonal trends and gaps in data, enabling robust forecasts of smoke impact and mortality trends. Prophet, a time-series forecasting tool developed by Meta, is well-suited for handling seasonal trends and data gaps, making it ideal for generating reliable forecasts of smoke impact and associated mortality. It is specifically designed to capture non-linear trends with yearly seasonality and is robust against outliers, missing data, and significant fluctuations, much like the spike in smoke impact during the 2017 and 2020 wildfires.

Data Sources

Wildfire Data

Wildfire data was obtained from the ScienceBase Catalog, which aggregates fire records maintained by the U.S. Geological Survey (USGS). This dataset which is available in GeoJSON and ArcGIS formats contains information about wildfires from 1835 to 2020. The specific file used, `USGS_Wildland_Fire_Combined_Dataset.json`, includes 30 attributes, but only acres burned and distance from Gresham were used to quantify the smoke impact. The dataset operates under public domain terms, with proper attribution to USGS.

To calculate distances, I converted wildfire polygons from the ESRI:102008 coordinate system to EPSG:4326 (latitude and longitude in decimal degrees), making them compatible with geographic distance calculations. This transformation allowed accurate distance measurements between Gresham and each wildfire using city location data derived from Google Maps. For smoke impact estimation, which will be discussed more in the coming section, I applied the inverse square law, using the acres burned and the square of the distance from Gresham.

Air Quality Data

Air quality data was sourced from the US Environmental Protection Agency (EPA) via its historical Air Quality Service (AQS) API. This API provides access to historical air quality monitoring data, including PM10 and PM2.5 levels. Monitoring in Multnomah County began in 1982 for PM10 and 1999 for PM2.5. The AQS API documentation outlines call parameters and query examples, and I used the county designation for Multnomah County to retrieve relevant data.

The air quality data was useful for validating trends in smoke exposure but was not a primary component of the smoke impact calculation due to its limited temporal alignment with wildfire and mortality data.

Chronic Respiratory Mortality Rates

Respiratory mortality data was obtained from the Institute for Health Metrics and Evaluation (IHME), covering 1980 to 2014 at the county level. This dataset contains age-standardized death rates (`mx`) for a range of respiratory illnesses. I filtered the dataset to focus on illnesses relevant to PM2.5 and PM10 exposure, excluding conditions not typically caused by wildfire smoke (e.g., silicosis, asbestos-related diseases, and coal workers' pneumoconiosis).

Filtered illnesses included:

- Chronic Obstructive Pulmonary Disease (COPD)
- Interstitial lung disease and pulmonary sarcoidosis
- Asthma (though mortality from asthma was later found negatively correlated with smoke impact).
- Chronic respiratory diseases
- Other chronic respiratory diseases
- Pneumoconiosis
- Other pneumoconiosis (Note: Both Pneumoconiosis variables were distinct from Pneumoconiosis attributed to coal workers)

To calculate the actual number of deaths, I multiplied the mortality rate (`mx`) by the population of Multnomah County for each year. The dataset's male and female mortality rates were aggregated to derive total annual deaths, ensuring consistency in the analysis.

Population Data

Population data for Multnomah County was retrieved from the Federal Reserve Economic Data (FRED) platform. The "Resident Population" dataset provides annual population estimates, adjusted for births, deaths, and migration. Using these population figures, I converted mortality rates into absolute death counts for respiratory illnesses.

FRED's data is freely available for non-commercial use, and I used Multnomah County's historical population from this series. This step was essential for translating relative mortality rates into actionable health metrics.

Data Licensing and Terms

1. **ScienceBase Catalog**: Public domain data; attribution to USGS is required for redistribution.
2. **AQS API (EPA)**: Data is available for educational and non-commercial use; full documentation is accessible online.
3. **IHME Data**:
    - Licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.
    - Non-commercial users must adhere to the IHME Free-of-Charge Non-Commercial User Agreement.
4. **FRED Data**: Free for personal, educational, and non-commercial use, provided proper attribution is given.

This combination of datasets enabled a comprehensive analysis of wildfire smoke impact on respiratory mortality in Gresham, Oregon, allowing for reliable calculations, correlations, and forecasting.

Smoke Impact Calculation

To create the smoke estimate/impact of wildfire smoke on Gresham, Oregon, I applied the inverse square law, a principle that models how intensity decreases as distance from a source increases. Similar to how light or sound diminishes as it spreads outward, wildfire smoke disperses as it travels further from its source, resulting in lower concentrations at greater distances. By incorporating this principle, the smoke estimate accounts for the physical reality of dispersion, providing a more realistic measure of smoke intensity in Gresham.

For example:

- A fire burning 10 miles away from Gresham will have a far greater impact than a similarly sized fire burning 100 miles away.
- Larger fires, regardless of distance, contribute more smoke to the overall impact. For instance, a fire burning 1,000 acres at 50 miles will still contribute significantly compared to a smaller 50-acre fire at the same distance.

Formula and Calculation

The formula I used for the smoke estimate is:

$$Smoke\ Estimate = \frac{Acres\ Burned}{(Distance\ from\ Fire)^2}$$

Variables:

- **Acres Burned**: Larger wildfires release more smoke, which increases their potential impact on air quality.
- **Distance from Fire**: As smoke travels farther from the fire, it disperses and loses intensity. Squaring the distance emphasizes this dispersion effect, as smoke at twice the distance will have only a quarter of the impact.

This formula was applied to every wildfire occurring within 650 miles of Gresham, capturing both nearby and distant fires that might affect the city. For each fire, I calculated its individual smoke impact and then aggregated these values across all fires within a given year to obtain the annual smoke impact.

Why Use the Inverse Square Law?

While advanced atmospheric models like HYSPLIT or BlueSky account for meteorological factors (like wind direction, topography), these require extensive computational resources and meteorological data, which were not feasible time-wise or available for this study. The inverse square law offers a straightforward estimate of smoke dispersion based on the size of the fire and its distance from the city. This method ensures that both proximity and fire size are appropriately weighted, aligning the model with how smoke physically spreads through the atmosphere. By aggregating the annual impacts, the model captures year-to-year variations in wildfire activity and provides a robust measure of smoke exposure for trend analysis given the data and time we had for the project.

Data Processing and Integration

To ensure accurate results, wildfire data was preprocessed as follows:

1. **Coordinate Transformation**: Fire polygons from the ScienceBase dataset were converted from the ESRI:102008 coordinate system to EPSG:4326 (decimal degrees). This enabled consistent distance calculations between fire locations and Gresham.
2. **Distance Calculations**: Distances between each wildfire and Gresham were calculated in decimal degrees, using Gresham's geographic coordinates as the reference point.
3. **Annual Aggregation**: Once the smoke impact for each fire was calculated, impacts were summed across all wildfires in a year to produce the total annual smoke impact.

Smoke Impact Forecast

Prophet was trained on the historical smoke impact data to forecast the smoke impact from 2025 to 2050 on Gresham, OR. Prophet works by breaking down time series data into three components:

1. **Trend**: Long-term changes in the data.
2. **Seasonality**: Cyclical patterns, though seasonality was less relevant here given the annual data.
3. **Noise**: Random fluctuations that do not follow predictable patterns.

The forecast provided estimates for future smoke impact, which were combined with historical smoke impact data to create a dynamic dataset spanning 1980–2050. This forecast served as the foundation for analyzing how rising smoke impact would influence future respiratory mortality.

Correlation Analysis of Smoke Impact on Respiratory Diseases

The next phase in evaluating the relationship between wildfire smoke impact and respiratory mortality, was a correlation analysis. A Pearson correlation was used to identify which respiratory illnesses were most affected by smoke exposure, as shown in Figure 6. The Pearson correlation was selected because it quantifies the strength and direction of linear relationships between two continuous variables (in this case, annual smoke impact and mortality rates for various respiratory illnesses). This method is ideal for an exploratory analysis as it provides a clear measure of association, helping prioritize illnesses that are most influenced by smoke exposure. The analysis revealed strong positive correlations for conditions such as COPD, chronic respiratory disease, and interstitial lung disease. This indicates that as smoke impact increases, mortality rates for these illnesses also rise. By focusing on conditions with strong positive correlations, such as COPD, the analysis highlights which health outcomes warrant further investigation and policy focus.

Forecasting Respiratory Mortality based on Smoke Impact

To forecast trends in respiratory mortality from 2025 to 2050, I used Prophet and linear regression. Prophet was chosen again for this analysis because it had already been used successfully to forecast smoke impact in earlier steps. By maintaining consistency in the modeling approach, I was able to seamlessly integrate the forecasted smoke impact data into a regression analysis for predicting future respiratory mortality trends. To forecast mortality, I used a linear regression model that was trained for each respiratory illness using the historical relationship between smoke impact and mortality rates. Forecasted smoke impact values (2025–2050) were then used to predict future mortality rates for each illness.

Ethical Considerations

Analysis of respiratory mortality is a sensitive matter, so attention was given to the ethical handling of the data. The data used in this study was sourced from the Institute for Health Metrics and Evaluation (IHME), which provides aggregated, anonymized datasets. This ensured that no personally identifiable information (PII) was included, safeguarding the privacy of individuals.

I ensured that all data was pre-aggregated at the county level, ensuring it could not be traced back to individual patients. I also ensured that there was transparency in the sources and methods used for data collection and processing were documented clearly, allowing for reproducibility and accountability. Lastly, while analyzing mortality data, care was taken to focus on trends and patterns that could inform public health policies without making unfounded causal claims or stigmatizing affected populations.

Findings

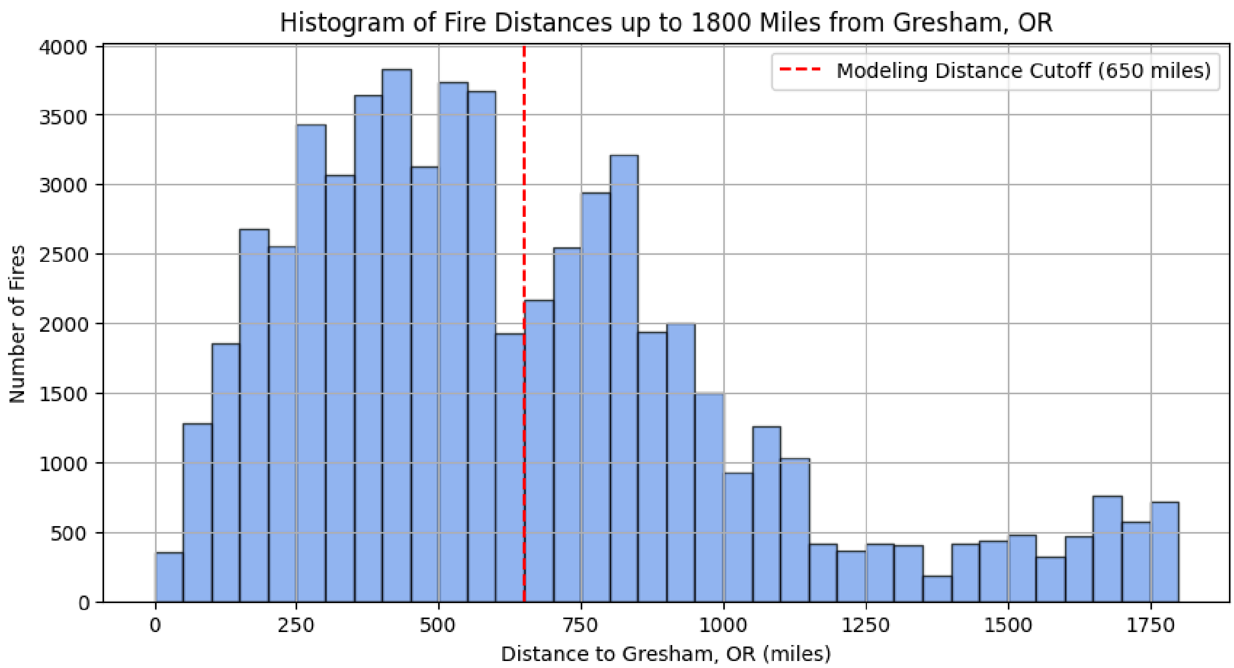

Figure 2. Wildfire Frequency Near Gresham, OR (1960-2021)

This histogram breaks down the number of wildfires that happened at various distances from Gresham, OR, all the way up to 1800 miles, with each bin covering 50 miles. The x-axis shows how far the fires were from Gresham, while the y-axis gives us the number of fires within each range. There's a red dashed line at 650 miles, which marks the distance cutoff we used for modeling smoke impacts on air quality. This visualization gives us a snapshot of how fire activity varies by distance, showing that most fires occur within a few hundred miles of the city.

This histogram visualizes the distribution of wildfire distances from Gresham, OR, within a maximum range of 1800 miles. The red dashed line marks the 650-mile cutoff used for smoke modeling. The distances were calculated using geospatial data of wildfire locations and Gresham, OR. The histogram bins represent intervals of distance, with the y-axis showing the number of fires that occurred in each distance range. The red line highlights the threshold used to include fires in the modeling of smoke impact within a smaller radius.

We can see that a significant number of fires happen within 650 miles of Gresham, which is cause for concern due to the wildfire impact.

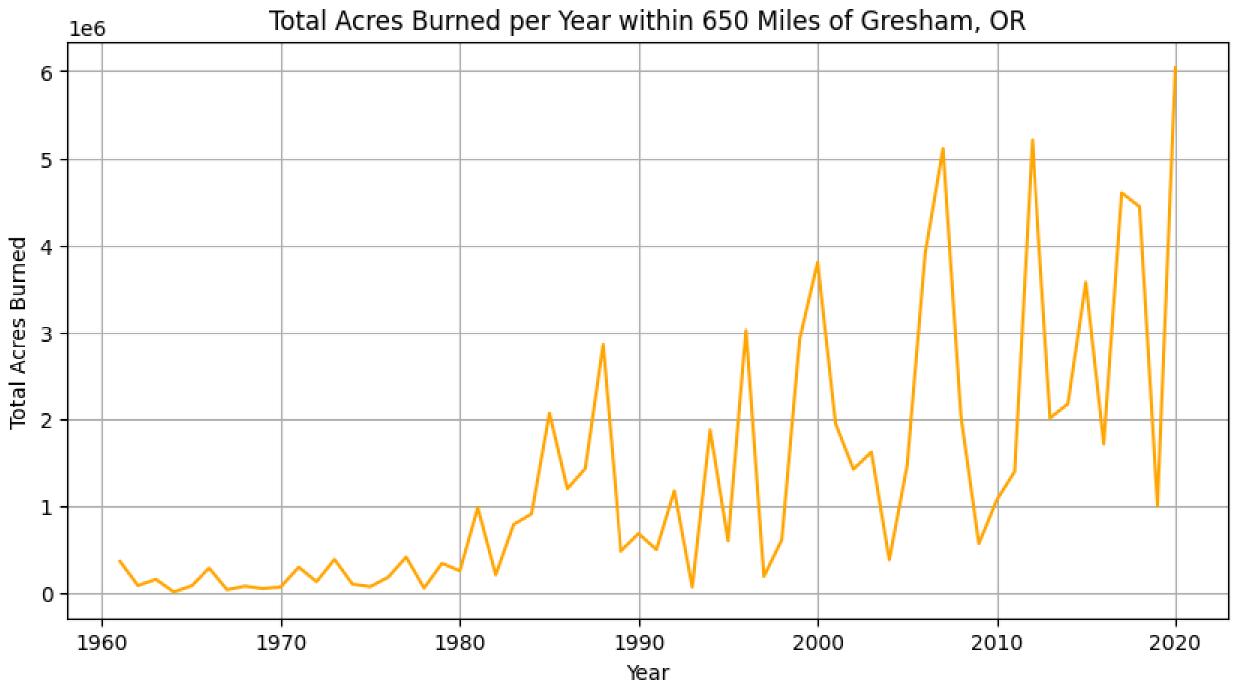

Figure 3. Total Acres Burned per Year within 650 Miles

This time series tracks the total acres burned each year from wildfires within 650 miles of Gresham. Years are on the x-axis, and the total acreage burned (in millions) is on the y-axis. It highlights fire patterns over time, showing low activity during some years and big spikes during others. The recent uptick suggests climate or other factors might be fueling these changes. Overall, this graph helps us understand wildfire trends near Gresham, which could help us anticipate future air quality impacts.

This figure illustrates the total acres burned annually within 650 miles of Gresham, OR. It highlights trends in wildfire activity over time and shows fluctuations in fire severity. Data on acres burned was aggregated from wildfire datasets, filtered to include only those fires within a 650-mile radius of Gresham, OR. Annual totals were computed, and the trend over time was plotted to identify patterns in wildfire behavior and its proximity to the city. We can see an upward trend in the number of acres burned, with major spikes starting in 2000 onward. Action needs to be taken to help mitigate the number of acres burned.

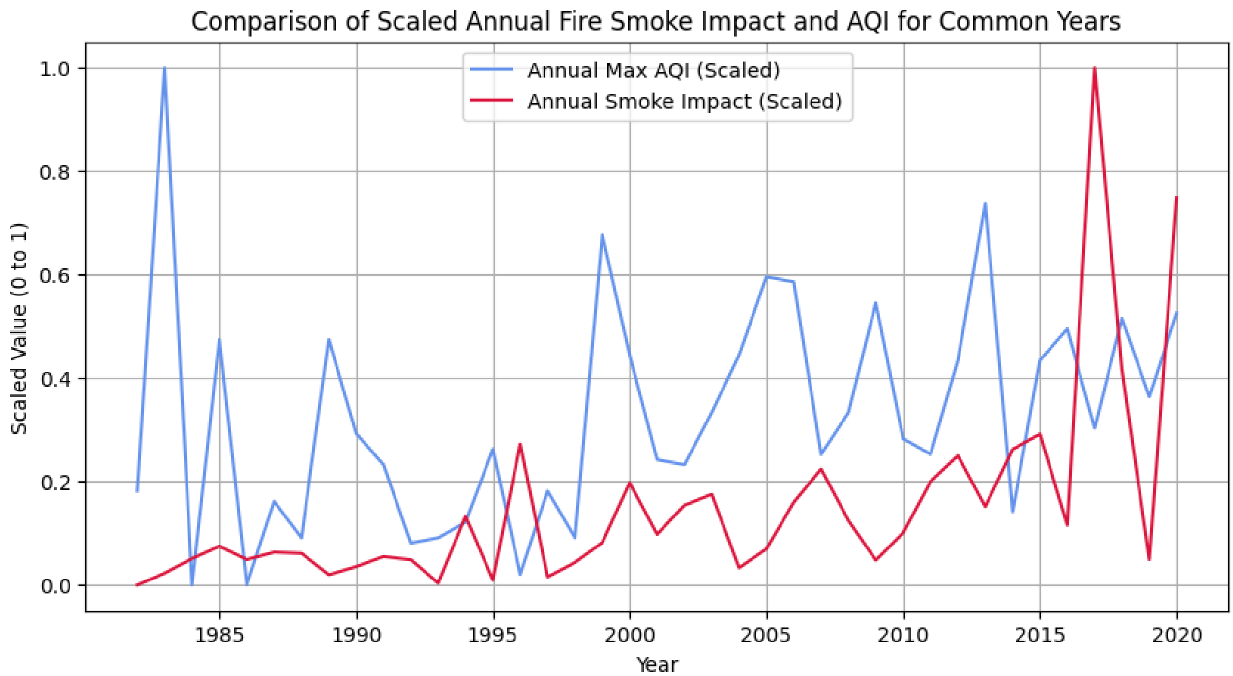

Figure 4. A Scaled Comparison of Annual Fire Smoke Impact and AQI

This graph lines up annual fire smoke impact estimates with Air Quality Index (AQI) values for Gresham, scaling both metrics between 0 and 1 for an easy, side-by-side comparison. Scaling helps us see how well these two trends match over time, even though smoke impact values are small (like 0.002), while AQI can reach much higher (e.g., 76+). The x-axis covers the years, and the y-axis shows the scaled values for each unit. Seeing both trends together lets us spot years when high smoke impacts seem to coincide with poor air quality.

This figure compares the scaled annual maximum Air Quality Index (AQI) and the scaled annual smoke impact values for years where both data sources overlap. The goal is to illustrate the relationship between smoke exposure and air quality over time. The AQI data represents annual maximum AQI values collected from environmental monitoring stations, while the smoke impact data was calculated using wildfire smoke estimates. Both datasets were scaled to a range of 0 to 1 to allow direct comparison despite differences in their original units. The comparison highlights trends and potential discrepancies between the two measures over time. It appears that when the AQI spikes, there is a lag in the spike of the smoke impact the following years.

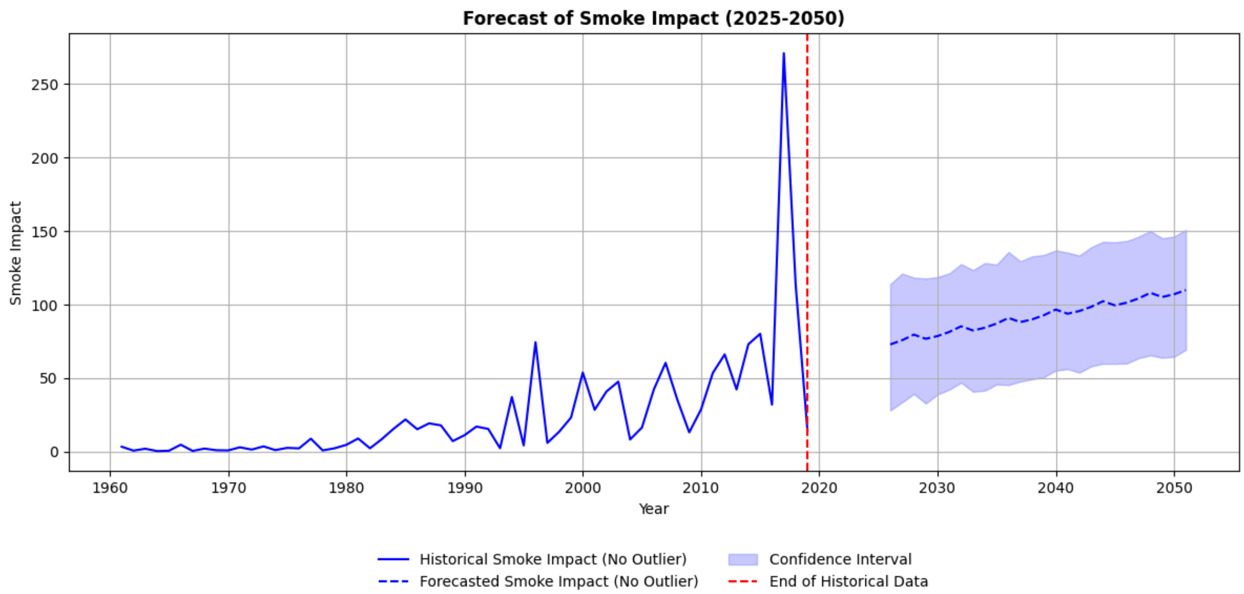

Figure 5. Forecast of Smoke Impact based on Historical Data

This figure illustrates the historical and forecasted impact of smoke from wildfires on public health. The chart highlights the increase in smoke impact over time and provides future projections with confidence intervals. The blue solid line represents the historical smoke impact (without outliers), while the blue dashed line shows forecasted values. The shaded blue region indicates the confidence interval of the forecast, showing the range within which future smoke impact is likely to fall. The vertical red dashed line marks the transition from historical data to forecasts. The x-axis represents the year, with historical data from 1960-2019, and forecasted data from 2025-2050. The y-axis represents the calculated smoke impact.

Historical smoke impact data was aggregated from wildfire records. Forecasting was performed using a time-series analysis tool (Prophet), incorporating trends and seasonality in the historical data. An outlier, the fire from 2020, was removed to enhance the forecast model's accuracy, as Gresham had not seen a fire that intense in its history prior to the fire. The confidence intervals were calculated to account for prediction uncertainty. The forecast shows an upward trend in smoke impact, meaning Gresham can expect increasing smoke exposure in the coming decades.

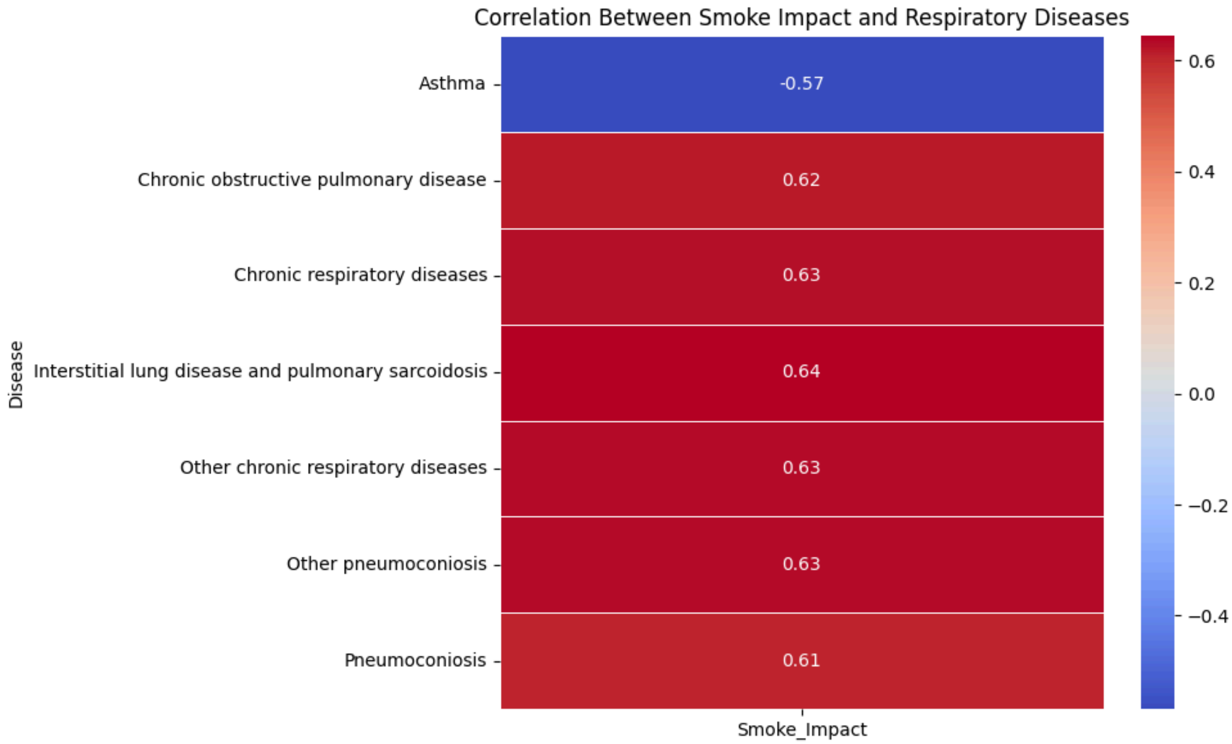

Figure 6. Correlation Between Smoke Impact and Respiratory Diseases

This figure presents the correlation between smoke impact and mortality from various respiratory diseases. Positive correlations indicate that higher smoke exposure is associated with increased mortality from certain diseases. Each bar represents a respiratory disease, with its correlation coefficient plotted on the x-axis. Positive correlations are shown in red hues, with higher intensity indicating stronger positive relationships. Negative correlations, like that for asthma, are shown in blue. On the x-axis, we have the correlation coefficient (ranges from -1 to +1, where values closer to +1 indicate a strong positive correlation and values closer to -1 indicate a strong negative correlation). The y-axis contains the disease names.

The data comprises historical mortality rates for various respiratory diseases and corresponding smoke exposure levels. Correlation coefficients were computed using statistical techniques, such as the default Pearson's correlation, to quantify the relationship between smoke impact and mortality for each disease. Most illnesses like chronic respiratory diseases showed strong positive correlations with smoke impact, meaning higher smoke levels are linked to higher mortality rates. Asthma mortality, however, showed a negative correlation, likely due to its preventability with proper care.

The figure shows Multonomah county and its surrounding area from the

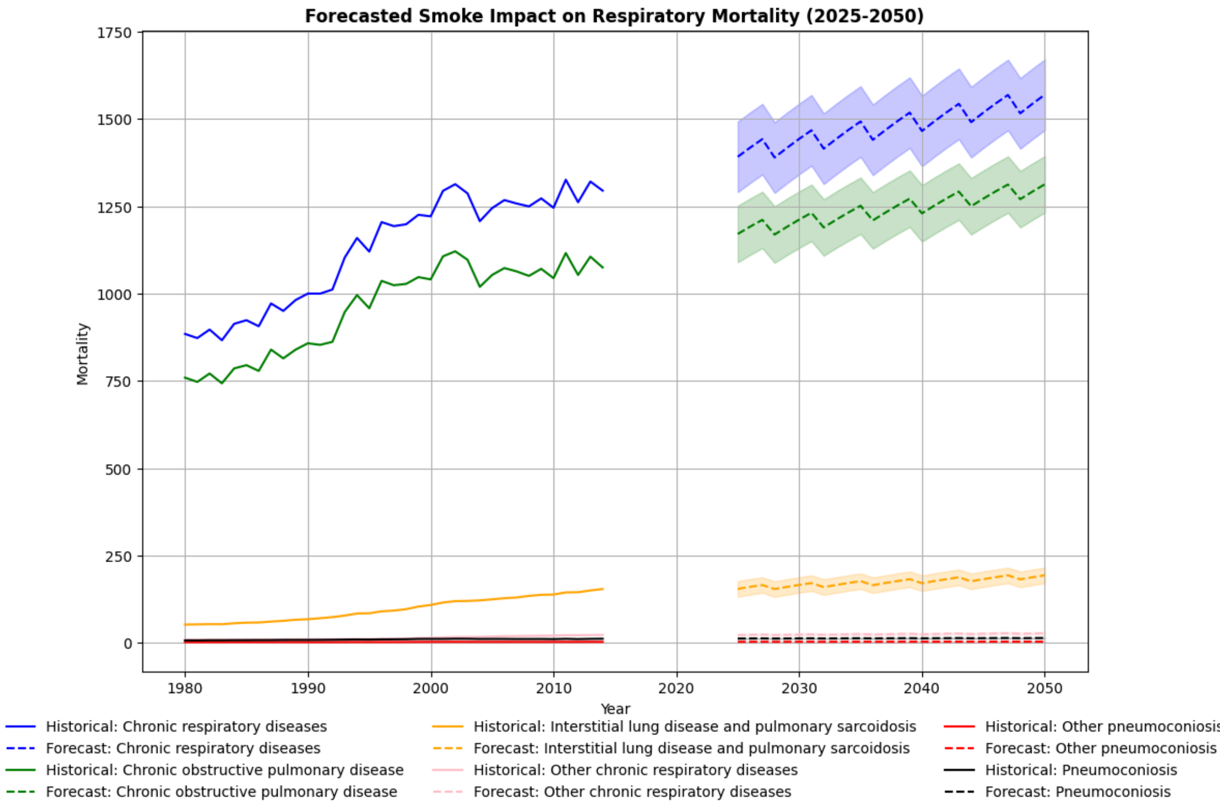

Figure 7. Forecasted Smoke Impact on Respiratory Mortality (2025-2050)

The figure shows the forecasted respiratory mortality based on historical data of the smoke impact and respiratory mortality. The x-axis represents the year (ranging from the historical period to 2050), and the y-axis represents the mortality count for each disease. The solid lines represent historical mortality data, while the dashed lines indicate forecasted mortality trends. The shaded regions around the forecasted lines denote the confidence intervals, illustrating the uncertainty in future estimates.

This figure presents historical and forecasted trends in mortality from various respiratory diseases as impacted by smoke exposure. It compares mortality rates for several disease categories, such as chronic respiratory diseases, chronic obstructive pulmonary disease (COPD), and others, with confidence intervals provided for forecasted data. The underlying data includes historical mortality statistics from IHME and smoke impact estimates derived from historical fire data. The forecasting model (Prophet) predicts future mortality, considering smoke exposure trends. Confidence intervals are calculated based on the model's uncertainty estimates. From this figure, Gresham can expect to see upward trends in mortality for all diseases except for Asthma. The blue, green, and yellow lines representing chronic respiratory, chronic obstructive pulmonary (COPD), and interstitial lung diseases are expected to show the highest increases in mortality rates through 2050, highlighting the need for proactive health measures to address illnesses worsened by PM2.5 exposure.

Discussion and Implications

The analysis indicates that both smoke impact and respiratory mortality in Gresham, Oregon, are projected to rise significantly through 2050 which we saw in our forecasted smoke impact and respiratory mortality (**Figure 5 & 7**). This is likely primarily due to the increasing frequency and intensity of wildfires that we saw in the amount of wildfires occurring near Gresham, and the amount of acres burned which represent their intensity (**Figure 2 & 3**). Chronic respiratory conditions such as COPD and interstitial lung diseases are expected to experience the most substantial increases in mortality, correlating strongly with elevated PM2.5 levels from wildfire smoke. Given that wildfires within a 650-mile radius substantially affect local air quality, regional collaboration in wildfire management is essential to protect the residents of Gresham.

Current Wildfire Mitigation Efforts

Gresham, Oregon, in collaboration with Multnomah County, has proactively implemented measures to address the escalating threat of wildfires and associated smoke impacts. A pivotal initiative is the Community Wildfire Protection Plan (CWPP) and the county's Multi-Jurisdictional Natural Hazards Mitigation Plan. Both plans aim to safeguard residents, property, natural resources, and infrastructure. The CWPP was developed with input from multiple stakeholders, including fire districts, state and federal agencies, city and county departments, and utility companies, ensuring a coordinated and comprehensive approach to wildfire mitigation.[14,15]

To enhance public awareness and preparedness, the state offers the Oregon Wildfire Risk Explorer[16], an interactive tool that provides a comprehensive view of wildfire risk and local fire history. This resource aids homeowners and community leaders in identifying the wildland-urban interface and assessing wildfire hazards at the property ownership level, thereby facilitating informed decision-making regarding wildfire prevention and mitigation strategies.

At the state level, Oregon has secured funding to bolster wildfire resilience. In 2024, U.S. Senators Jeff Merkley and Ron Wyden announced the allocation of $7 million for the EPA's wildfire grant program[17,18]. This program supports efforts by states, tribes, local governments, and nonprofit organizations to prepare for and protect against wildfire smoke hazards, including the development of smoke mitigation plans and community education initiatives.

Recommendations for Action

To mitigate the growing threat of wildfires and smoke impacts, Gresham and the surrounding region could adopt several strategies. Structural mitigation and vegetation management involve encouraging property owners to use fire-resistant building materials and maintain defensible spaces around their homes. This approach could reduce wildfire risk by up to 75% when combined with vegetation management. Initial efforts could begin within six months, with long-term benefits realized over 10 to 25 years.

Fuel management through prescribed burns and mechanical thinning is another effective measure to reduce fuel loads in fire-prone areas. These treatments require careful planning and environmental assessments, which could take one to two years, with ongoing implementation thereafter. Costs range from $200 to $2,000 per acre, depending on terrain and treatment methods.

Finally, Gresham already has great tools out there for awareness and plans to help residents, but further community education and engagement programs are essential to get these tools out there. Programs to inform residents about evacuation plans and personal safety measures could be developed within six months and maintained as ongoing outreach efforts. Costs for these programs would vary based on the scope and delivery methods. Together, these strategies provide a comprehensive approach to enhancing resilience against wildfires in the region.

Limitations

Several limitations could affect the accuracy and applicability of the findings in this study. One major limitation is the data coverage. The mortality data used in the analysis only extends to 2014, which means recent trends in respiratory health impacts, especially given the increasing frequency and intensity of wildfires in recent years, are not captured. This gap restricts the ability to fully understand how more recent wildfire activity might influence respiratory health outcomes.

Another limitation lies in the simplified dispersion model. The use of the inverse square law to estimate smoke impact provides a straightforward and computationally efficient framework. However, it does not account for critical meteorological variables such as wind speed, direction, and atmospheric stability, which play a significant role in smoke dispersion. Additionally, topographical features like mountains and valleys can alter the movement of smoke, potentially concentrating it in certain areas, which the model does not address.

The absence of hospital admission data is another key limitation. By focusing solely on mortality, the study does not capture the broader spectrum of health impacts associated with wildfire smoke exposure, such as increased emergency room visits, long-term respiratory issues, or non-fatal exacerbations of chronic diseases. Including this data could provide a more comprehensive understanding of the health burden caused by wildfire smoke.

Lastly, the lagged health effects of smoke exposure present a challenge. Many of the long-term impacts of PM2.5 exposure, such as chronic respiratory diseases, may take years to fully manifest. This delay can lead to an underestimation of the true health burden of wildfire smoke, as these effects may not be immediately visible within the study's time frame.

Despite these limitations, the methods used offer a transparent and replicable approach to estimating smoke impact and forecasting health outcomes. They provide a valuable foundation for further research and for informing public health and policy decisions in Gresham.

Conclusion

In this project, I aimed to answer two main research questions: **What is the future smoke impact of wildfires based on historical data? and How does this smoke impact affect respiratory mortality in Gresham, Oregon?** Through my analysis, I found that both wildfire smoke impact and respiratory mortality rates are expected to rise significantly by 2050. Chronic respiratory diseases, COPD, and interstitial lung disease showed the strongest correlations with smoke exposure, highlighting the serious public health risks that wildfires pose to the region.

This study also highlights the role of human-centered data science in tackling real-world problems. By using simple but effective methods, like the inverse square law for estimating smoke dispersion and Prophet for forecasting trends, I was able to provide insights that are not only actionable but also easy for community leaders and residents to understand. The project focused on the health risks faced by vulnerable groups, such as people with pre-existing respiratory conditions, showing how data science can be used to prioritize the well-being of those most at risk.

Additionally, I ensured that the data used was anonymized and that the analysis was transparent and ethical, making the findings accessible and meaningful for decision-makers. This project has shown me how important it is to balance technical accuracy with the need to address human concerns in data science.

Overall, this study helps Gresham better understand how wildfire smoke affects respiratory health and provides a starting point for creating policies that protect residents. It has also shown me how data science can connect technical analysis with real-world impacts, making it a powerful tool for solving public health challenges.

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