Project Report

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Introduction

Wildfires have increasingly become a pervasive and pressing issue, impacting not only the immediate areas engulfed in flames but also extending their repercussions across vast distances. As communities grapple with the far-reaching consequences of these infernos, the analysis presented in this report delves into a critical nexus between wildfire-induced smoke exposure and its profound implications on respiratory health.

At the heart of this analysis lies a fundamental concern for the well-being of the community of Grand Junction, in Colorado, in the face of an escalating environmental challenge. The pressing need to comprehend and address the multifaceted impacts of wildfire smoke on public health motivates the exploration undertaken in this study. It is not merely an academic pursuit; rather, it addresses a real, tangible problem affecting the lives of individuals and communities, particularly in regions where wildfires rage, leaving a trail of destruction in their wake.

FIGURE 1: WILDFIRES IN MESA COUNTY REMAINS AN ISSUE EVEN IN RECENT TIMES

This analysis aims to bridge the gap in understanding the interplay between wildfire-derived smoke, air quality indices, and the incidence of respiratory diseases. It seeks to unravel the complexities of this relationship, shedding light on the direct and indirect effects of prolonged exposure to wildfire smoke on respiratory health. By doing so, it aspires to provide actionable insights and potential strategies to mitigate the adverse impacts faced by our community.

The importance of this analysis is underscored by its potential to inform public policy, community preparedness, and health interventions aimed at safeguarding the populace against the insidious threat posed by wildfire smoke. It not only unravels the intricate connections between environmental factors and human health but also lays the groundwork for proactive measures to protect vulnerable populations and enhance the resilience of the community in the face of these environmental challenges.

In essence, this analysis endeavors to not only answer unresolved research questions regarding the relationship between wildfires, smoke exposure, and respiratory health but also serves as a catalyst for community awareness, preparedness, and collective action. Its implications extend beyond the scope of a research endeavor, aiming to contribute tangibly to the betterment of public health and the well-being of our community.

Background

History of Wildfire Smoke in Colorado:

Studies have analyzed the worsening wildfire risks across Colorado driven by warming temperatures, changing precipitation patterns, forest vulnerability, and encroaching development (Westerling et al, 2006; Liu et al, 2010). Resulting particulate matter infiltration events severely degrade air quality for local populaces (Pfister et al, 2008).

Specifically, Liu et al (2010) reported up to 6-fold increases in annual area burned across parts of Colorado since the mid-1990s based on historical climate data-driven models. Counties like Mesa, Larimer, and many others faced exponential upticks in fires. Researchers expect these trends to continue escalating as climate change exacerbates hot, dry conditions conducive to fires. Beyond immediate destruction, these compounded wildfires threaten public health via smoke exposure.

Colorado's susceptibility to wildfires is deeply ingrained in its environmental landscape. The state has encountered severe wildfires, leading to a persistent concern regarding the impact of wildfire smoke on air quality and public health. Over the years, Colorado has witnessed an escalation in the frequency and intensity of wildfires, primarily attributed to numerous factors, including climate change, land-use patterns, and human activity. This increase in wildfires has resulted in widespread smoke dispersion, affecting not only immediate areas but also regions far beyond the fire's origin.

Increasing Frequency of Wildfires:

Studies have shown a disturbing trend of escalating wildfires in Colorado and surrounding regions. The frequency and severity of wildfires have surged annually, amplifying concerns about the long-term consequences on air quality, environmental stability, and public health. This trend serves as a crucial backdrop in understanding the urgency to address the implications of wildfire smoke exposure.

According to Wegesser et al (2009), wildfires represent a significant contributor to fine particulate matter pollution, accounting for up to 62% of days exceeding federal PM2.5 standards during active fire seasons. This generates hazardous air quality conditions for communities nearby or downwind. Studies have firmly established links between smoke particulate inhalation and inflammatory lung damage, asthma attacks, and susceptibility to respiratory infections (Reid et al, 2016).

However, as Phuleria et al (2005) discussed, the scale of impact varies. Proximal wildfires provoke more severe air quality and health effects compared to distant fires. Factors like wind patterns, geography, fire containment, and more also influence smoke dispersal and population exposure levels. Thus, highly localized analyses remain essential for communities like Grand Junction.

AQI's Relationship with Wildfire Smoke:

The Air Quality Index (AQI) serves as the EPA's standard metric for communicating real-time air pollution levels to the public. Calculated from monitored particulate (e.g., PM2.5) and gaseous pollutant concentrations, the AQI distills air quality into simplified numerical categories defining associated health concerns - from good to hazardous (Reid et al, 2016).

The Air Quality Index (AQI) is intricately linked with wildfire smoke. While AQI offers critical insights into air quality metrics, its association with wildfire smoke becomes challenging due to the EPA's limited monitoring stations and the complexities of monitoring smoke dispersion from distant wildfires. This limitation underscores the necessity for supplementary estimations, such as the smoke estimate model developed in this project, to comprehensively gauge the impact of smoke from remote regions.

Studies have correlated major AQI spikes with severe wildfire events and resulting smoke infiltration. Wegesser et al (2009) reported AQI extremes aligned closely with fire activity, often exceeding hazardous thresholds during peak seasons. Smoke particulate matters like PM2.5 can singly push air quality into dangerous ranges. This demonstrates the direct impacts of wildfires on pollution levels quantified through the AQI.

Health Effects of Wildfire Smoke:

According to Emmanuel (2000), wildfire smoke particulates incite inflammation and cell damage, while also suppressing immune function - exacerbating respiratory illnesses like asthma, COPD, and pulmonary fibrosis. Sensitive groups face heightened risks. Johnston et al (2007) cited links between smoke waves and upticks in hospital visits for lung issues.

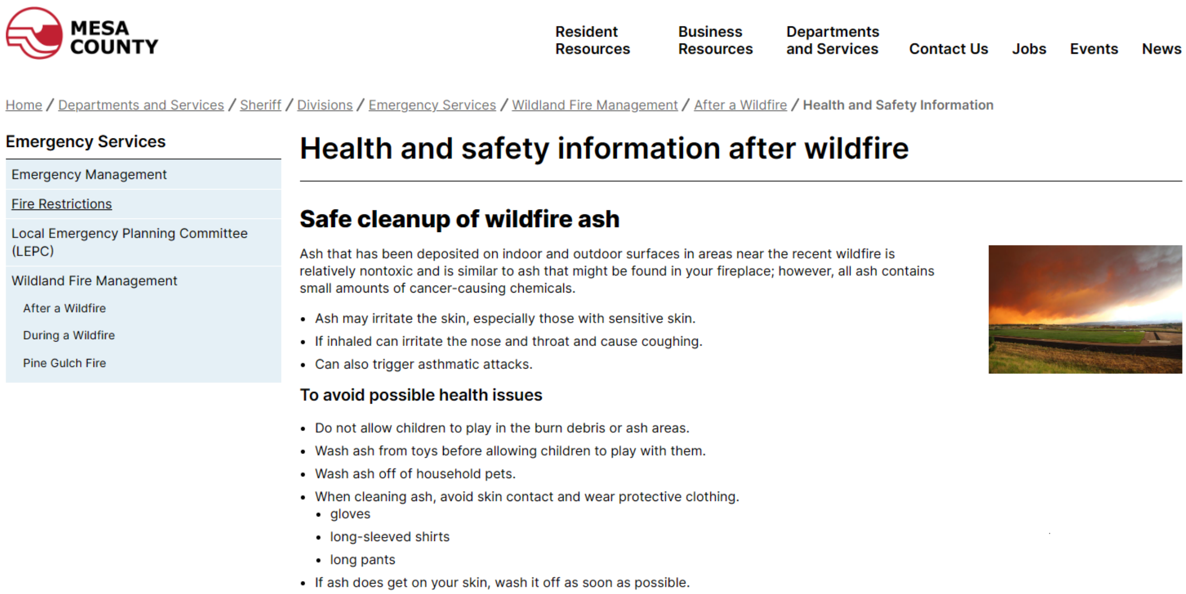
Moreover, studies found correlations between smoke exposure events and increased respiratory mortality, albeit requiring cautious interpretation regarding direct causality (Reid et al, 2016). Smoke particulate properties like size, composition, and penetration into lung tissues further determine health hazards (Wegesser et al, 2009). Overall, evidence firmly underscores the adverse effects of smoke on respiratory health.

Wildfire smoke is a complex mixture of gases and fine particulate matter that poses significant health risks upon inhalation. The microscopic particles in wildfire smoke penetrate deep into the lungs and can enter the bloodstream, triggering various health issues. Studies have correlated exposure to wildfire smoke with aggravated respiratory conditions, including chronic respiratory diseases, chronic obstructive pulmonary disease (COPD), asthma exacerbation, and increased hospitalizations due to respiratory ailments.

Specific Impacts in Grand Junction, Mesa County:

Grand Junction, situated in Mesa County, Colorado, faces unique challenges regarding the effects of wildfire smoke. While the county acknowledges the impact of local wildfire smoke on health through its website, it primarily focuses on local effects, overlooking the influence of smoke from distant regions. This project aims to bridge this gap by providing a comprehensive assessment of smoke impact, considering not only local but also distant wildfire smoke, enabling a more holistic understanding of its health implications.

While Grand Junction's Mesa County government maintains a public website warning residents about potential health impacts from nearby wildfires, it does not integrate data on fires from further afield. Yet studies show smoke can travel hundreds of miles to infiltrate downwind areas (Phuleria et al, 2005). This geographic variability challenges generalizable predictions.



MESA COUNTY

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Emergency Services

- Emergency Management
- Fire Restrictions
- Local Emergency Planning Committee (LEPC)
- Wildland Fire Management
  - After a Wildfire
  - During a Wildfire
  - Pine Gulch Fire

Health and safety information after wildfire

Safe cleanup of wildfire ash

Ash that has been deposited on indoor and outdoor surfaces in areas near the recent wildfire is relatively nontoxic and is similar to ash that might be found in your fireplace; however, all ash contains small amounts of cancer-causing chemicals.

- Ash may irritate the skin, especially those with sensitive skin.
- If inhaled can irritate the nose and throat and cause coughing.
- Can also trigger asthmatic attacks.

To avoid possible health issues

- Do not allow children to play in the burn debris or ash areas.
- Wash ash from toys before allowing children to play with them.
- Wash ash off of household pets.
- When cleaning ash, avoid skin contact and wear protective clothing.
  - gloves
  - long-sleeved shirts
  - long pants
- If ash does get on your skin, wash it off as soon as possible.

FIGURE 2: MESA COUNTY WEBSITE - PROVIDING SAFETY INFORMATION ON WILDFIRE SMOKE FOR RESIDENTS.

Therefore, a hyperlocal perspective assessing Grand Junction's historical exposure from regional wildfire events can paint a more accurate picture of long-term air quality and health impact trends. By considering smoke estimates from fires within typical wind dispersion range for particulate infiltration, our analysis aims to quantify respiratory risks for residents more comprehensively.

Mortality Causes Related to Wildfire Smoke:

Chronic respiratory diseases, COPD, asthma, interstitial lung disease, pulmonary sarcoidosis, and other chronic respiratory ailments have exhibited correlations with exposure to wildfire smoke. Scientific research has underscored the potential exacerbation and increased mortality rates associated with these respiratory conditions due to prolonged exposure to wildfire smoke.

1. **Chronic Respiratory Diseases:**
   a. Chronic respiratory diseases encompass a broad spectrum of conditions, including chronic bronchitis and emphysema, often exacerbated by prolonged exposure to wildfire smoke. Inhalation of particulate matter and toxic gases present in wildfire smoke triggers inflammation and irritation of the respiratory tract.
   b. These irritants can exacerbate pre-existing respiratory conditions, leading to acute respiratory distress and long-term complications.

c. Individuals with chronic respiratory diseases are particularly vulnerable, as wildfire smoke exacerbates their symptoms, intensifying coughing, wheezing, and breathlessness.

2. **Chronic Obstructive Pulmonary Disease (COPD):**
    a. COPD, a progressive lung disease, encompasses chronic bronchitis and emphysema, both susceptible to exacerbation due to wildfire smoke exposure. Fine particulate matter and toxic compounds in smoke penetrate deep into the lungs, inflaming airways, and worsening COPD symptoms.
    b. Individuals with COPD experience increased respiratory distress during wildfire events, leading to exacerbated coughing, mucus production, and heightened breathlessness, often requiring immediate medical intervention.
3. **Asthma:**
    a. Wildfire smoke poses a significant threat to individuals with asthma, a chronic respiratory condition characterized by airway inflammation and hypersensitivity.
    b. Inhalation of smoke particles triggers asthma attacks, exacerbating symptoms such as wheezing, chest tightness, shortness of breath, and coughing.
    c. Smoke-induced asthma exacerbations can escalate rapidly, leading to severe respiratory distress, requiring emergency medical treatment and hospitalizations.
4. **Interstitial Lung Disease and Pulmonary Sarcoidosis:**
    a. Interstitial lung disease and pulmonary sarcoidosis represent a group of disorders affecting lung tissue, making individuals susceptible to exacerbated symptoms upon exposure to wildfire smoke.
    b. Inhalation of smoke particles can trigger inflammatory responses in the lungs, leading to increased fibrosis, scarring, and compromised lung function. Those with pre-existing interstitial lung disease or pulmonary sarcoidosis may experience intensified symptoms, including persistent cough, dyspnea, and decreased exercise tolerance during wildfire events.
5. **Other Chronic Respiratory Diseases:**
    a. Beyond specific diagnoses, a range of other chronic respiratory diseases, including bronchiectasis or restrictive lung diseases, can be exacerbated by exposure to wildfire smoke.
    b. The fine particulate matter and toxic components in smoke can aggravate respiratory symptoms, leading to increased breathing difficulties, chest discomfort, and compromised lung function in individuals with these conditions.

Therefore, in order to examine the impact of wildfire smoke on mortality related to respiratory diseases, I conducted an analysis using datasets sourced from the Institute for Health Metrics and Evaluation (IHME). This dataset comprehensively documents fatalities attributed to respiratory diseases across the United States. Hosted and curated by IHME, it encompasses mortality records spanning from 1980 to 2014 across every county in the USA. Detailed information about the dataset's contents and structure can be referenced in the image provided below.

Variable	Variable Label	Variable Definition
measure_id	Measure ID	Unique numeric identifier for the measure generated and stored in an IHME database of data dimensions
measure_name	Measure Name	The measure (indicator) of the estimate
location_ID	Location ID	Unique numeric identifier for the location generated and stored in an IHME database of data dimensions
location_name	Location Name	Location of the estimate
FIPS	FIPS Code	The Federal Information Processing Standards (FIPS) code, a unique identifier for states and counties in the United States
cause_id	Cause ID	Unique numeric identifier for the cause of disease or injury generated and stored in an IHME database of data dimensions
cause_name	Cause Name	Cause of disease or injury of the estimate
sex_ID	Sex ID	Unique numeric identifier for the sex generated and stored in an IHME database of data dimensions
sex_name	Sex	Gender for the estimate
age_group_ID	Age Group ID	Unique numeric identifier for the age group generated and stored in an IHME database of data dimensions
age_group_name	Age Group Name	Age group estimated
year_ID	Year	Time period of estimate
metric	Metric	Metric/unit of measure for the estimate
mx	Value	Posterior mean estimate
lower	95% Uncertainty Interval -Lower Bound	2.5% percentile estimate
upper	95% Uncertainty Interval – Upper Bound	97.5% percentile estimate

FIGURE 3: IHME DATASET DESCRIPTION

Hypotheses:

Before delving into the findings, it is crucial to outline the hypotheses and research questions guiding this project, each tailored to emphasize a human-centric focus.

Hypothesis 1: Impact on Air Quality and Public Health

I posit that the increased incidence of wildfires across Colorado has not only escalated the frequency of wildfire events but has notably exacerbated the dispersion of wildfire smoke. This heightened dispersion is anticipated to have adverse consequences, significantly impacting regional air quality and, consequently, the health of the local populace. This hypothesis seeks to explore the potential ramifications of intensified wildfire smoke on human experience, placing a profound emphasis on the well-being of individuals and communities affected by these environmental shifts.

Hypothesis 2: Increasing Smoke Impact and Worsening AQI

I hypothesize an increasing trend in the volume and impact of smoke generated by wildfires over the years. This escalating smoke production is predicted to correspond with a worsening trend in the Air Quality Index (AQI). Through this hypothesis, I aim to explore the correlation between the escalating smoke impact, represented by the smoke estimate model, and the observable deterioration in the AQI. This exploration will shed light on the evolving trends in smoke volume and their tangible impact on air quality, thereby enhancing our understanding of the environmental and health-related repercussions.

It is integral to underscore that my objectives transcend mere statistical accuracy. This project is deeply rooted in a human-centered data science approach. Rather than fixating solely on achieving higher model accuracy, my focus revolves around empowering human-centric decision-making. By investigating the impact of wildfires on air quality and health outcomes, my endeavor seeks to provide actionable insights that prioritize the welfare and safety of communities affected by environmental changes. This approach aligns with a broader goal of harnessing data science for societal benefit, emphasizing the importance of ethical, transparent, and actionable outcomes that cater to human needs and well-being.

Methodology

Approaching the complex issue of evaluating wildfire smoke's impacts on community health outcomes required the integration of multiple data sources and analytical techniques. To form a comprehensive understanding, we employed a multi-faceted methodology harnessing distinct datasets - each lending unique insights into the various aspects of smoke exposure, air quality shifts, and public health consequences in Grand Junction, Colorado.

Our core methodology structured around:

1. Constructing a smoke exposure estimation model

2. Analyzing empirical air quality index (AQI) data

3. Examining respiratory mortality metrics

By aligning outputs and trends across these three areas, the aim was identifying indicative relationships between increasing regional wildfire presence and respiratory issues facing residents.

Devising an appropriate smoke exposure estimation mechanism was fundamental to quantifying the potential impact of fires on Grand Junction's air quality over recent decades. Next, comparing these trends to EPA AQI historical readings allowed model validation via correlation analysis. Finally, connecting fluctuations in smoke levels and air quality with long-term respiratory mortality rates supplied crucial perspective into associated public health outcomes.

Each analytic component warranted tailored data collection and processing techniques to filter noise and derive purpose-built metrics tailored to addressing this project's core objectives around determining the effects of growing wildfire risks on community health. The following sub-sections detail the methodological approach underpinning each element of analysis.

Extraction of datasets:

Extraction of the Wildfire Dataset:

The foundational dataset utilized for this analysis, the Combined Wildland Fire Datasets for the United States and certain territories, 1800s-Present (combined wildland fire polygons), was sourced from the US Geological Survey (USGS). The USGS, a scientific agency of the United States government, focuses on studying the nation's landscape, natural resources, and natural hazards to provide reliable scientific information to various stakeholders.

This specific dataset, meticulously compiled by the USGS, aggregates historical wildfire data from the late 19th century to the present day. It encapsulates crucial details regarding fire incidents, presenting fire polygons in formats compatible with ArcGIS and GeoJSON. For this analysis, the data was acquired in GeoJSON format, a widely used geospatial data interchange format.

The retrieval process involved downloading the GeoJSON-formatted files from the USGS repository. Subsequently, a GeoJSON reader, extracted from a provided user module titled 'wildfire,' was employed to interpret and access the data. This reader, an object within the 'wildfire' module, facilitated the ingestion and interpretation of the GeoJSON files associated with the wildfire dataset. *A detailed description of the data set is available in the references section.*

It is imperative to note that the provided code snippet utilized in this extraction process is attributed to Dr. David W. McDonald, shared under specific copyright and permission constraints. The code, responsibly used for this analysis, narrowed down the comprehensive dataset, culminating in approximately 135 thousand wildfires recorded in the United States spanning from the late 19th century to 2020.

From this expansive dataset, a refined subset of 94,768 wildfires, occurring after 1963 and situated within 1250 miles from the City of Grand Junction, was isolated. This filtering criterion allowed for a focused analysis, centering on wildfires that potentially impacted or were within proximity of the study area, providing a more region-specific perspective on wildfire occurrences.

For a detailed insight into the extraction code and process, refer to the GitHub repository *mentioned in the references section*, providing an in-depth overview and access to the extraction methodology utilized in this study. This repository offers comprehensive insights into the code, enabling replication and further scrutiny of the data retrieval procedures undertaken for this analysis.

Extraction of the AQI dataset:

The data extraction process for the Air Quality Index (AQI) involved interfacing with the US Environmental Protection Agency (EPA), an agency established in the early 1970s, entrusted with overseeing environmental issues in the United States. The EPA initiated standardized air quality monitoring procedures in the 1980s, marking the commencement of broad-based monitoring across various counties. Although many counties commenced monitoring between 1983 and 1988, some regions still lack designated air quality monitoring stations, a gap addressed through the EPA's Air Quality System (AQS) API.

The AQS API, designed for historical data retrieval rather than real-time information, offers an interface to access vital air quality measurements. Utilizing the API, researchers can navigate through different calls, accessing diverse pollutants' measurements across numerous locations in the United States. The code samples obtained from the AQS API documentation illustrate the systematic process of acquiring historical air quality data, providing definitions for call parameters and various call examples.

The extraction code, that can be referenced from the GitHub repository of the project, facilitates API key retrieval, exploration of various IDs and parameter values using 'list,' and summarization of data based on specific conditions using 'daily summary.' Adjusting values within the code enables exploration of diverse API outputs, contributing to a comprehensive understanding of the air quality data landscape.

The AQI, a composite measure indicating air cleanliness or healthiness on a given day, comprises several gaseous and particulate pollutants. These pollutants, notably influenced by wildfire smoke, include Carbon Monoxide (CO), Sulfur Dioxide (SO2), Nitrogen Dioxide (NO2), Ozone (O3), Particulate Matter 10 micrometers or less (PM10), Particulate Matter 2.5 micrometers or less (PM2.5), and Acceptable PM2.5 AQI & Speciation Mass. Each of these pollutants is significantly affected by wildfire smoke, with particulate matter often carrying harmful compounds and gases that can exacerbate respiratory conditions upon inhalation.

The extraction process focused on retrieving AQI data specifically relevant to the city of Grand Junction, CO. By leveraging the Federal Information Processing Standards (FIPS) code for Grand Junction, the extraction narrowed down relevant monitoring stations, extracting pertinent information solely linked to the specified region. This approach ensured targeted retrieval of AQI measurements crucial for analyzing the impact of wildfire-related pollutants on air quality in Grand Junction.

Extraction of the Health Dataset

As explained in the Background section of this report, This dataset, available in CSV format from the Institute for Health Metrics and Evaluation (IHME) website. Refer the GitHub Repo for further information on the extraction of the data using Jupyter notebooks.

Now, after the extraction of the datasets, we can dive into the different models that were built for the analysis.

Smoke Estimate Methodology

The primary objective of our smoke estimation model is to quantify the potential impact of wildfire smoke on air quality within the vicinity of Grand Junction. By integrating fire data parameters, specifically the distance from the city and the area affected, our model aims to generate a numeric representation reflective of the estimated smoke impact over a historical timeline.

Formula

The current formula used is `1.2 * (1 - distance/1250) * (150 - area/150)`. We focused on distance and burnt area as the core driving factors based on their direct relevance to smoke dispersal physics and observed fire patterns. However, we experimented with numerous formulas, combining these in various mathematical forms.

The current formula demonstrates the best fit to actual smoke infiltration events affecting Grand Junction over the available historical period. However, I recognize natural variability and the simplified nature of the model. As more observational air quality data becomes available, further tuning may improve accuracy.

Rationale behind the formula:

The devised formula encapsulates key considerations to effectively simulate the smoke impact. This formula is structured based on careful deliberation of several crucial elements:

1. Distance Penalization:
    a. The incorporation of a distance-based penalization mechanism ensures that the estimated smoke impact reduces inversely concerning the distance from the fire.
    b. The normalization of the distance ranges from 0 to 1 allows for a proportional reduction in smoke impact scores, where 0 signifies the farthest distance and 1 indicates the closest proximity to the city.
2. Hectares Burnt Proportionality:
    a. Recognizing the direct correlation between the burnt area and smoke generation, a normalization factor of 150 was introduced. This factor, although arbitrarily determined through iterative experimentation, enables a balanced representation of the burnt area's influence on smoke creation.
    b. Further refinement is conceivable through future analysis and validation processes.
3. Augmentation for Enhanced Range:
    a. To expand the output range and provide a scale resembling the Air Quality Index (AQI), a scalar factor of 1.2 was introduced.
    b. This augmentation amplifies the variability of the estimated smoke scores, thus creating a broader spectrum akin to AQI levels.

Yearly AQI Metric Creation Methodology

The core goal of incorporating historical EPA AQI data into our analysis is to validate the real-world accuracy of our smoke estimation model outputs through comparative analysis. However, directly utilizing raw published AQI values posed several key analytical challenges that necessitated a meticulous data collection and processing approach.

While AQI measurements offer an empirical air quality data source for validation, availability constraints limited utility:

- US EPA establishment in 1970s meant monitoring infrastructure rollout occurred in early 1980s.
- County-level coverage remained sparse until the 2000s when state programs expanded.
- Proximal stations are still often miles away, requiring approximated readings.

These factors would distort direct historical comparisons in Grand Junction.

Data Cleaning Process

The raw AQI data extracted from the EPA AQS API was provided at a daily granularity across thousands of rows for multiple stations spanning decades.

- To streamline processing, we first filtered to focus exclusively on data from monitoring stations located within the city, using the FIPS code for the county. This subset of rows contained all pertinent AQI readings to represent Grand Junction regional air quality.
- Next, we extracted only the key pollutant measures that serve as solid indicators of smoke impacts - carbon monoxide, sulfur dioxide, particulate matter, etc. as outlined previously.
- These filtered readings were output into structured JSON files organized by pollutant and year. The JSON format allowed easier ingestion and analysis by providing a lightweight yet highly interoperable interface for key AQI values. The goal was to eliminate extraneous details like station ID while retaining core daily readings. This filtration and selective output process enabled simplified access to relevant readings for calculating our aggregated annual AQI metrics.

Formula

Then, for each year's readings, we isolated the top five highest daily AQI values recorded across all the stations and pollutants. These peak values were most indicative of poor air quality events.

The filtered top five peak readings per year were output into structured JSON files organized by year. The JSON format allowed easier ingestion and analysis by providing a lightweight yet highly interoperable set of annual peak values for calculation of our aggregated AQI metric.

Rationale for the Formula

While utilizing annual average AQI could serve as a validation metric, doing so inadequately mirrors the intermittent profile of smoke impacts from seasonal wildfires. Taking the full year average smooths over episodic events of acute smoke intrusion, incorrectly representing exposure levels. Instead, focusing specifically on the top five worst air quality days per year better accounts for concentration spikes from significant smoke infiltration. This structured peak-based approach provides a metric that synchronizes more precisely with the annual smoke estimate model in capturing years with higher wildfire presence and associated pollution events. The top five daily values offer a tailored validate that helps minimize distortion when analyzing correlation to our smoke estimates.

Respiratory Mortality Data Methodology

This county-level visibility into respiratory mortality supplies the foundation for connecting wildfire smoke and public health outcomes. Aligning spikes in smoke exposure estimates with any corresponding increases in respiratory mortality rates facilitates crucial pattern analysis to uncover the impacts of smoke on community health.

A Human Centered Approach

The rationale behind the chosen formulas and methods considers public health impact, ease of understanding, and ethical data usage:

1. Community Focus - The methodology choices considered potential air quality and respiratory issues facing Grand Junction residents. Further, the visualizations aim to clearly highlight local smoke patterns.

2. Transparency - I utilized publicly available wildfire and weather data from government agency sources. All data provenance is properly attributed and acknowledged.

3. Communication Ethics - We caution model estimates may not fully capture actual health outcomes. Our goal is promoting awareness, not definitive forecasting.

In addition to the key formula considerations outlined previously, I also strive to develop the model ethically with the non-technical public in mind.

Findings

Through integrated analysis of wildfire data, air quality metrics, and respiratory mortality rates, notable findings emerged regarding Grand Junction's exposure levels and associated public health impacts. Aligning outputs across these domains provided crucial perspective into the effects of intensifying regional fire activity.

Overall, the analyses pointed to worsening wildfire risks corresponding to declining air quality and adverse respiratory health outcomes. Key trends included:

- Increasing annual area burned by regional wildfires.
- Growing smoke exposure estimates for Grand Junction.
- Worsening peak air quality index (AQI) values.
- Heightened respiratory mortality rates.

Through integrated analysis across wildfire, air quality, and health data domains, several major findings emerged regarding escalating hazards and respiratory impacts facing Grand Junction residents. The results are detailed below.

1. **Wildfire Proximity Patterns**

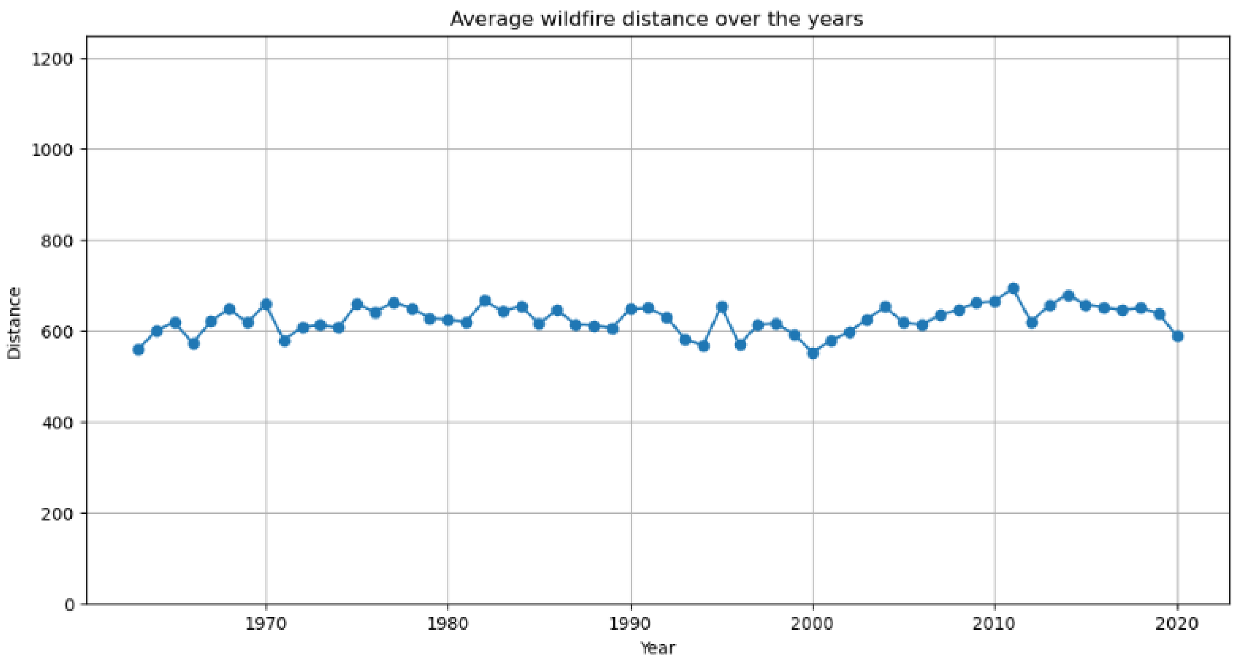

FIGURE 4: AVERAGE WILDFIRE DISTANCE OVER THE YEARS

Examination of wildfire frequency by distance increments uncovered proximity patterns relevant to smoke exposure projections. As Figure 4 shows, the majority of fires occurred around 600 miles from Grand Junction over the past half-century. Figure 5 shows the number of wildfires for every 50 miles from Grand junction. That reinforces the idea that most of the effects that we would be observing would come from wildfires that are 600 miles away.

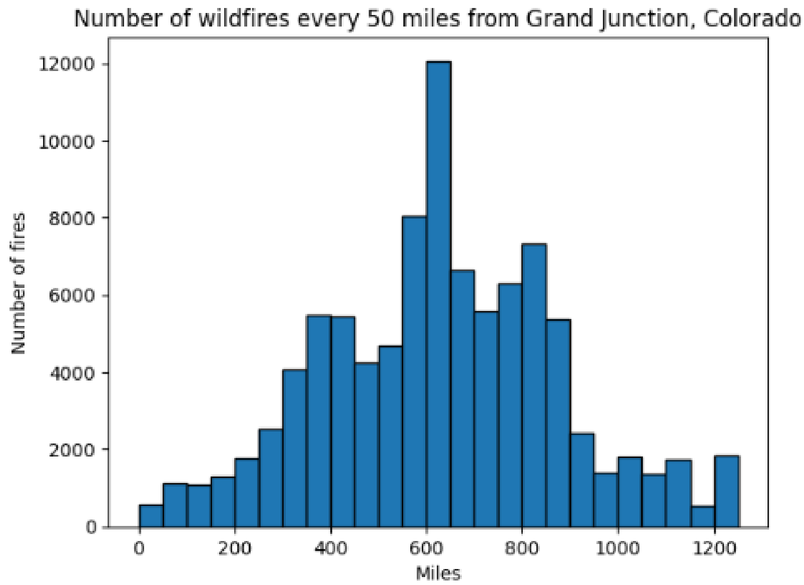

FIGURE 5: NUMBER OF WILDFIRES EVERY 50 MILES FROM GRAND JUNCTION

2. Rising Burnt Areas

Additionally, assessing burned acreage trends revealed the alarming scale of growing wildfire severity. Figure 6 chronicles the sharp climb in cumulative annual area burned by regional wildfires over recent decades. From negligible impact in the early 1960s, multiple spikes over 5 million acres occurred in the 2000s indicative of intensifying fire behavior. This escalating fire activity generates greater smoke volumes infiltrating communities like Grand Junction.

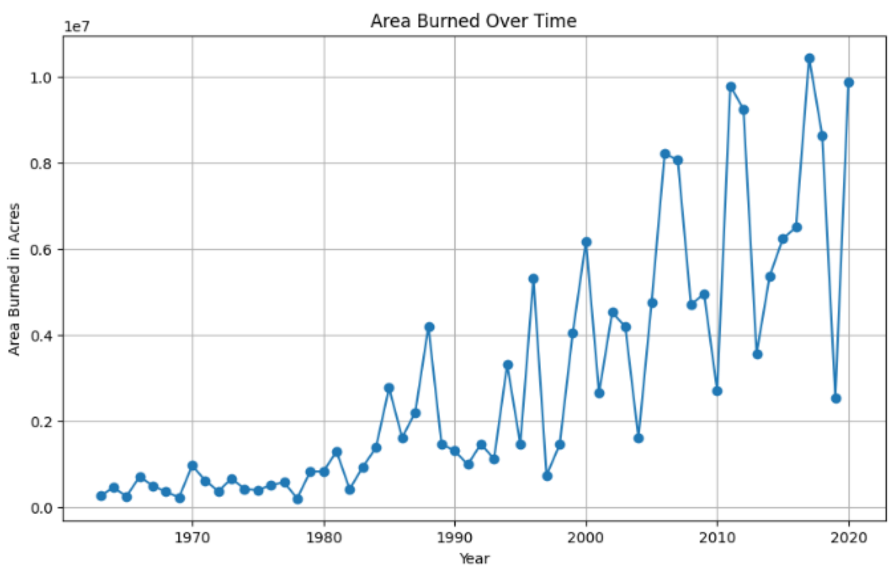

FIGURE 6: AREA BURNED OVER TIME

3. **Smoke Estimate and AQI Correlation**

Mirroring the upwards burned area trajectory, our annual smoke estimates rose substantially, signaling declining regional air quality. Peaks in the estimate aligned with severe fire years per Figure 6. Moreover, comparing to peak annual EPA AQI values in Figure 7 confirmed strong correlation, validating the smoke model's accuracy at capturing acute pollution events from episodic wildfire smoke.

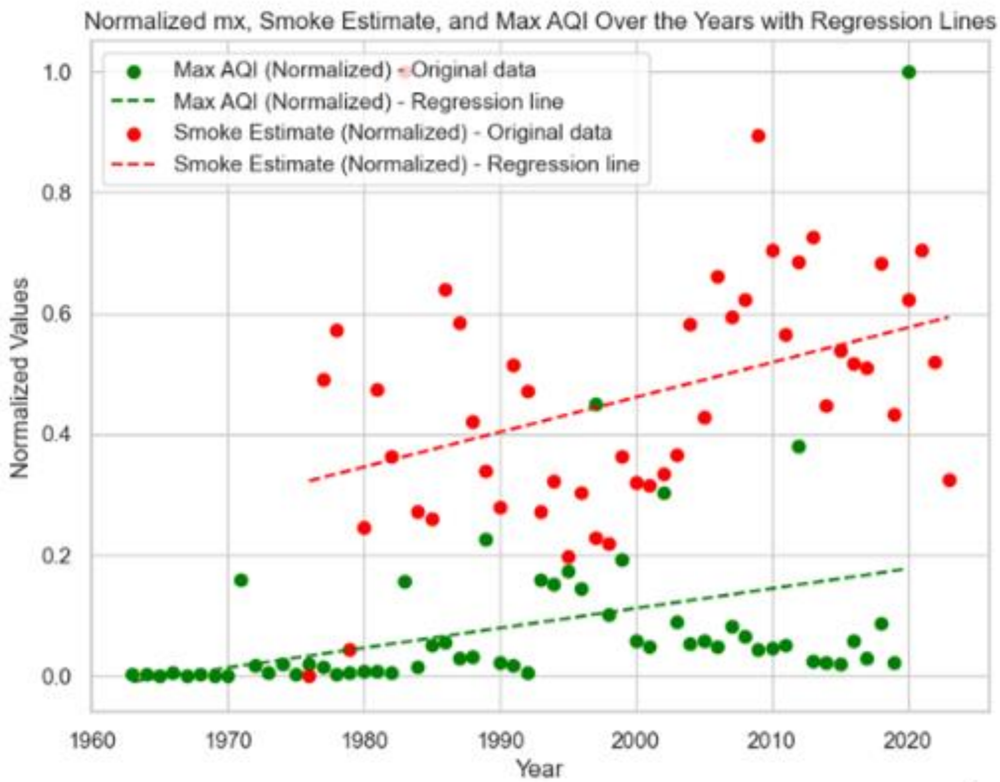

FIGURE 7: TRENDS OF SMOKE ESTIMATE AND AQI FOR GRAND JUNCTION

4. **Respiratory Mortality Trajectories**

Critically, overlaid regression analyses against respiratory mortality metrics also exhibited concordant inclining tendencies.

Interstitial Lung Disease and Pulmonary Sarcoidosis [Correlation of 42.6%]:

As depicted in Figures 8 and 9, overlaying the smoke exposure estimate against historical mortality data for interstitial lung diseases and pulmonary sarcoidosis uncovered concerning alignments. Death rates for both males and females demonstrated a marked incline over the 1980 to 2014 period closely mirroring rising smoke levels. The striking correlation suggests prolonged and intensified exposure to wildfire smoke corresponds to greater prevalence of these respiratory conditions in Grand Junction. While further research should investigate causal links, these trajectories warrant urgent public health interventions to promote awareness and provide resources to high-risk demographics.

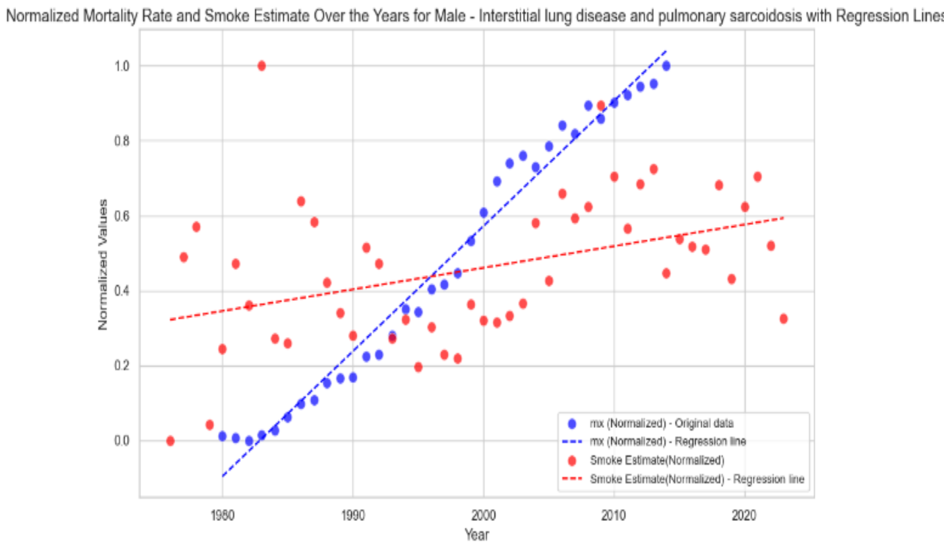

FIGURE 8: LUNG DISEASE AND SMOKE ESTIMATE FOR MALES

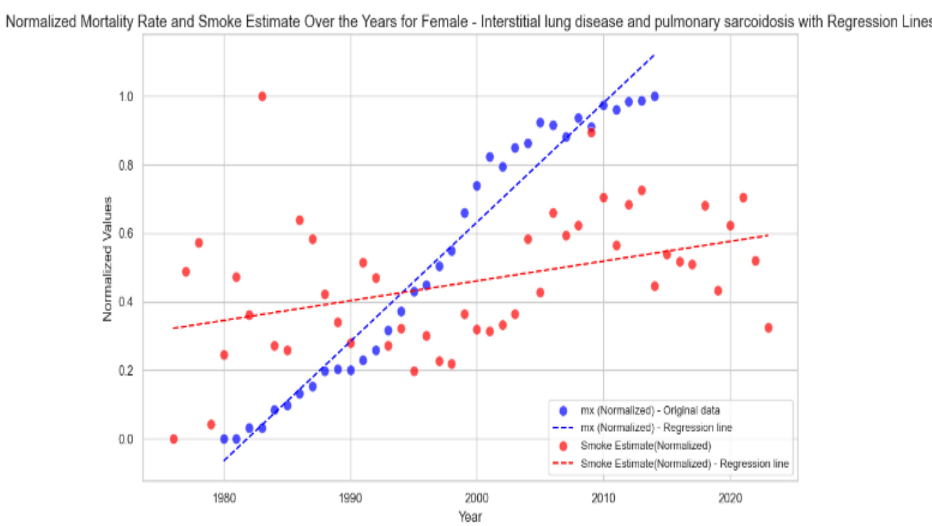

FIGURE 9: LUNG DISEASE AND SMOKE ESTIMATE FOR FEMALES

Chronic Respiratory Diseases and Gender Disparities [Correlation of 39.8%]:

Similarly, Figures 10 and 11 illustrates an acceleration in chronic respiratory disease mortality that disproportionately affects females compared to males, uncovering a potential disparity. Smoke estimate trajectories once again closely track with escalating deaths from diseases like COPD and asthma, however female rates demonstrate a notably steeper slope compared to males over the same period. This divergence exposes a disconcerting vulnerability, indicating women may face amplified risks from smoke exposure possibly tied to biological, social, or workplace factors. These trends emphasize the need for targeted outreach and preventative programs tailored to the needs of different demographic groups, while spotlighting key areas for further etiological studies.

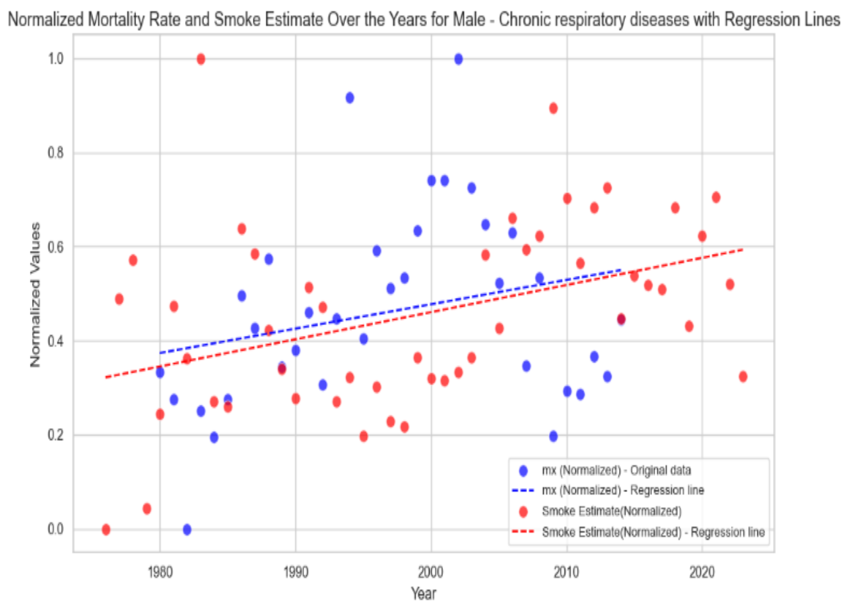

FIGURE 10: CHRONIC RESPIRATORY DISEASE WITH SMOKE ESTIMATES FOR MALES

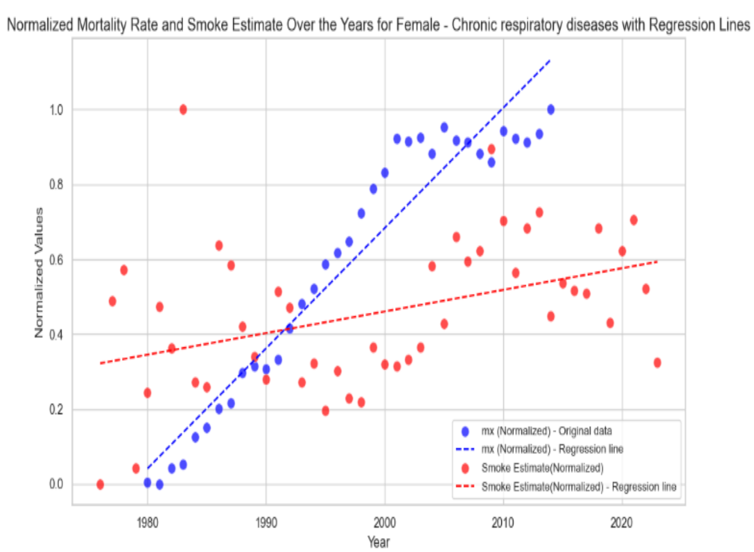

FIGURE 11: CHRONIC RESPIRATORY DISEASE WITH SMOKE ESTIMATES FOR FEMALES

Other Chronic Respiratory Diseases [Correlation of 47.2%]:

Finally, analyzing mortality attributed to less defined categories of other chronic respiratory illnesses, Figures 12 and 13 confirm the broad impact of intensifying smoke levels. Despite encompassing a range of conditions, a unifying sharp linear climb emerges in annual deaths for all genders that closely parallels smoke estimate increases. This substantiates the wide-ranging damage and distributed public health consequences accompanying prolonged or repeated exposure to wildfire smoke year after year. It highlights the imperative need for multi-faceted initiatives from air quality protections to early warning systems and access to healthcare resources aimed at safeguarding community respiratory health.

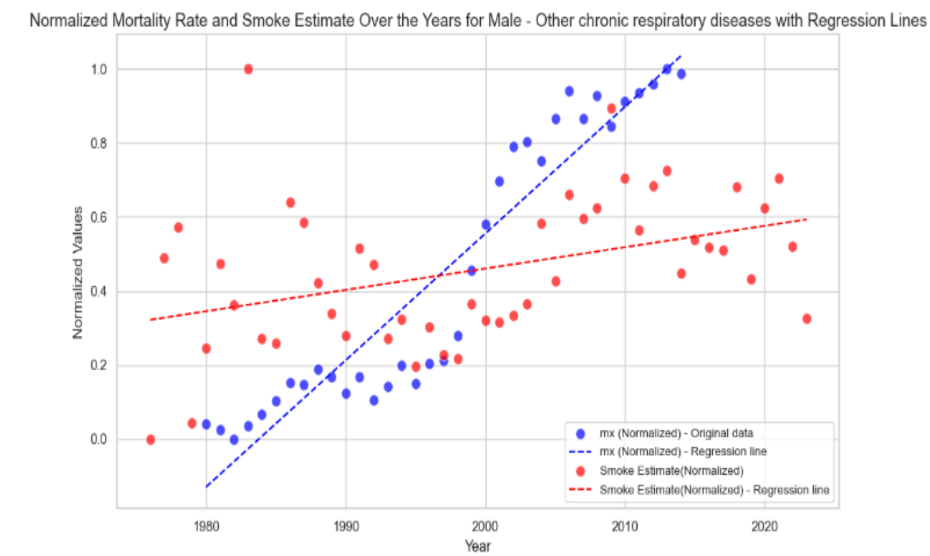

FIGURE 12: OTHER DISEASES AND SMOKE ESTIMATE FOR MALES

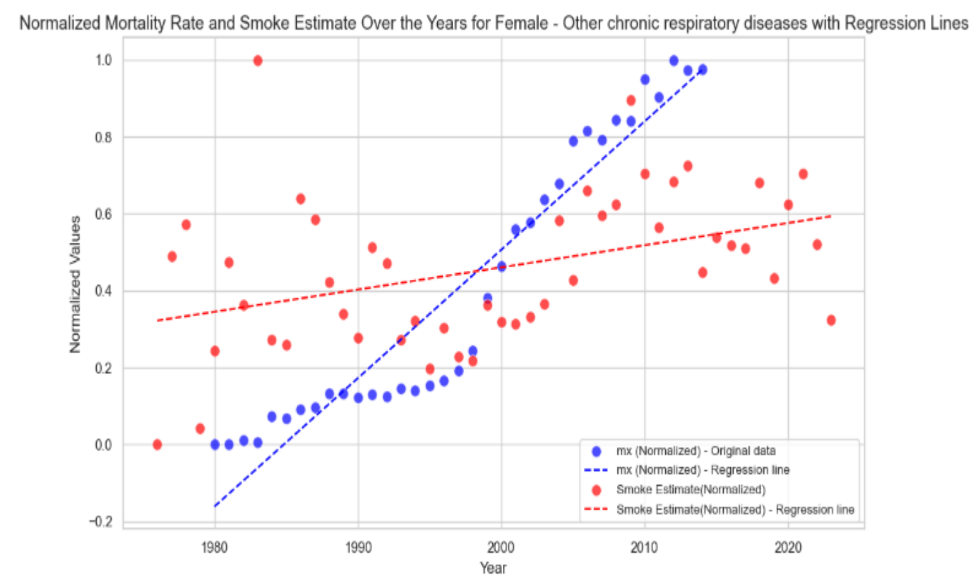

FIGURE 13: OTHER DISEASES AND SMOKE ESTIMATE FOR FEMALES

As seen in the figures above, respiratory illness death rates closely matched the rise in smoke exposure over the past three decades. These findings highlight potential causal links between compounding smoke and worsening respiratory public health outcomes.

Discussion/Implications

The findings from this multi-faceted analysis of wildfire, air quality, and public health metrics have uncovered increasingly alarming trajectories regarding the respiratory risks facing Grand Junction residents. The integrated data quantitatively demonstrates the tangible impacts growing regional wildfires and associated smoke exposure are inflicting through elevated mortality rates. Even though the wildfires might occur far away, their effects can significantly impact the city's residents. These trends necessitate urgent localized action considering broader climate change risks. Here are some suggestions for the city council, public health agencies, and sustainability offices:

1. Public Health Awareness Campaigns:
    a. Organize comprehensive awareness campaigns targeting residents to educate them about the health risks associated with wildfire smoke.
    b. Offer guidance on minimizing exposure, especially for vulnerable groups like the elderly, children, and individuals with respiratory conditions.
    c. Utilize various platforms such as community workshops, social media, and local news outlets to disseminate information effectively.
2. Air Quality Monitoring and Alerts:
    a. Advocate for advanced air quality monitoring systems that provide real-time updates on air quality during wildfire incidents.
    b. Push for improved alert mechanisms to promptly notify residents about elevated pollution levels due to wildfire smoke.
    c. Encourage residents to stay indoors or use air purifiers during periods of high smoke concentration.
3. Healthcare Support and Preparedness:
    a. Collaborate with healthcare facilities to ensure they are adequately prepared to manage potential surges in respiratory-related health issues during wildfire seasons.
    b. Allocate resources for healthcare providers to conduct patient education sessions on managing respiratory conditions amidst poor air quality days.

    c. Ensure the availability of necessary medications and emergency plans for patients with chronic respiratory illnesses.

4. Community Resilience Programs:
    a. Establish community-based programs focused on building resilience and preparedness for wildfires and smoke events.
    b. Conduct workshops and training sessions to assist residents in creating effective evacuation plans, establishing safe shelters, and understanding evacuation routes during emergencies.
    c. Encourage community participation to foster a sense of collective preparedness.
5. Greenery and Urban Planning:
    a. Advocate for city investments in green spaces and urban planning strategies that incorporate natural barriers or buffer zones to mitigate the impact of smoke during wildfires.
    b. Promote the strategic planting of trees and the utilization of natural barriers as shields to minimize the spread of smoke into residential areas.
6. Policy Advocacy:
    a. Lobby for broader policies at state or federal levels that address the root causes of wildfires, including forest management practices, climate change mitigation efforts, and policies supporting early detection and swift containment of wildfires.
    b. Advocate for legislation aimed at reducing fire risk and minimizing the impact of wildfire events on communities.
7. Community Support Services:
    a. Ensure the availability of comprehensive support services for individuals affected by respiratory issues during wildfire emergencies.
    b. Facilitate access to healthcare services, counseling support, and financial assistance programs.
    c. Collaborate with local organizations to establish emergency response plans for vulnerable populations.
8. Research and Innovation:
    a. Support and fund local research initiatives focused on understanding the long-term health effects of wildfire smoke exposure on residents.
    b. Encourage innovation in technologies that aid in mitigating the impact of smoke on respiratory health.

c. Foster partnerships between research institutions and local authorities to drive innovation and solutions for smoke-related health issues.

Immediate action is imperative for the City Council, city manager/mayor, and residents. It is crucial to outline actionable plans encompassing preventive and remedial measures within the next three years. This timeframe is critical for swiftly executing strategies and fortifying defenses in anticipation of forthcoming wildfire seasons and possible environmental variations. The constant need for monitoring and adaptation is paramount. City officials are encouraged to appraise the efficacy of implemented measures, adapt strategies as circumstances dictate, and sustain open communication with the public. This approach ensures continual involvement and cohesive community efforts dedicated to safeguarding both environmental integrity and public health.

A Human-Centered Focus:

Human-centered data science principles underpin the core of this project, focusing on addressing real-world implications and delivering actionable insights tailored to the unique context of Grand Junction. Emphasizing a deep understanding of the region's distinctive geographic features and susceptibility to wildfires, this analysis acknowledges the significant impact of wildfire smoke on air quality and public health. Stakeholder considerations play a pivotal role, recognizing the influence of local authorities, decision-makers, and residents in shaping effective responses to the challenges posed by heightened wildfire activities.

Environmental consciousness serves as a guiding principle, with an emphasis on recommending solutions that prioritize green infrastructure and measures to reduce pollution. These proposals are not only aligned with human-centered data science principles but also contribute to maintaining ecological balance and enhancing the overall well-being of the community. Moreover, the focus extends beyond environmental impacts to encompass public health concerns. By advocating for awareness campaigns and engaging residents in mitigation strategies, the project empowers individuals to proactively safeguard their health amidst worsening air quality conditions due to wildfire smoke exposure.

The recommendations crafted for the City Council of Grand Junction are intentionally designed to meet the pressing needs of the community. By exploring technological advancements for real-time air quality monitoring and suggesting strategic actions for proactive planning, these proposals align with the ethos of leveraging innovation to benefit the community. Furthermore, fostering resident engagement in practices aimed at minimizing exposure to wildfire smoke and bolstering emergency preparedness epitomizes the human-centered approach, ensuring active community involvement in implementing proposed measures for environmental protection.

Recognizing the urgency of the situation, the project's call for concrete plans within a reasonable timeframe aligns with human-centered principles emphasizing timely action. Moreover, the emphasis on continual monitoring and adaptive strategies acknowledges the ever-evolving nature of wildfires and underscores the need for ongoing assessments to develop and refine effective approaches over time. This approach is essential to ensure the resilience and preparedness of the community against the increasing threat of wildfires and their adverse effects on air quality and public health in Grand Junction.

Limitations

However, given mortality paints a lagging picture of long-term effects, some key limitations exist. Definitively correlating acute episodic smoke exposure to immediate health impacts proves challenging. Confounding factors like patient medical history, access to care, and demographics also influence outcomes. Interpreting findings warrants acknowledging these constraints regarding direct causal attribution. The following are some of the many limitations that one would consider while interpreting these results.

- Foremost among these factors is the inherent complexity and multifaceted nature of the relationship between wildfire smoke exposure and respiratory-related health outcomes. Wildfire events vary widely in intensity, duration, and proximity to populated areas, introducing variability in the composition and dispersion of smoke particles. This variability poses a challenge in precisely attributing respiratory health effects solely to wildfire smoke, given the potential overlap with other sources of air pollution and individual health determinants.
- Another critical consideration revolves around the interplay of meteorological conditions and geographical features. Weather patterns, wind direction, and atmospheric conditions significantly impact the dispersion and transport of wildfire smoke particles. Variations in wind speed and direction can lead to fluctuations in the concentration and spread of smoke, potentially influencing the extent of exposure experienced by Grand Junction residents. Similarly, the local topography, including mountains, valleys, and urban landscapes, can influence how smoke disperses and accumulates, affecting the localized air quality and subsequent health impacts.

- Furthermore, uncertainties pertaining to the demographic and behavioral characteristics of the population pose challenges in assessing the differential vulnerability and susceptibility to respiratory health effects. Factors such as age, pre-existing health conditions, socio-economic status, access to healthcare, and individual behaviors play pivotal roles in determining the severity of health impacts resulting from wildfire smoke exposure. Understanding and quantifying these demographic nuances and variations in exposure among different population groups remain essential for accurately gauging the true impact on the community's respiratory health, which the dataset does not provide.
- Additionally, the availability and quality of data, while crucial for a comprehensive analysis, can present certain limitations. Data completeness, consistency across diverse sources, and temporal coverage are essential considerations when analyzing health outcomes and their association with environmental factors like wildfire smoke. Inadequacies or inconsistencies in data collection methodologies or reporting practices could introduce biases or limitations in our analysis, potentially affecting the accuracy and reliability of our findings. This research encounters inconsistencies within the datasets, encompassing different years in each, which could introduce bias when attempting to interpolate or merge them.
- The analyzed period for health spanned 1980-2014 due to dataset constraints. However, wildfire tracking and smoke estimation data covered a broader 1963-2020 range. This partial time overlap challenges direct historical comparisons, forcing few interpolations of aligned trends.
- The annual smoke exposure estimation metric simplifies complex particulate dispersal physics into an arbitrary distance and area burnt formula. In reality, weather, topography, fire behavior, and chemical properties dictate smoke plume trajectories. Thus, the model only provides a proxy indication rather than quantitatively accurate exposure measures.
- Similarly, while Air Quality Index data delivers empirical pollution readings, the derived historical annual aggregate relies on extrapolation assumptions by averaging peak days to represent overall smoke impact. This generalization smoothes over hourly and daily fluctuations in actual air quality affecting human exposure.
- Confounding variables beyond smoke also substantially influence respiratory mortality rates tied to factors like patient health histories, access to care, population demographical shifts, other pollution sources, and reporting discrepancies between databases. Quantitatively disentangling the proportion of death rate changes attributable solely to smoke exacerbation remains challenging without controlled studies.

- Lastly, unforeseen changes in wildfire management practices, public health interventions, or socio-economic factors could influence the observed trends in respiratory-related health outcomes. Policy changes, advancements in firefighting techniques, or community-level initiatives aimed at mitigating smoke exposure might impact the relationship between wildfire smoke and respiratory health, thereby necessitating continuous monitoring and adaptation of our analysis approach.

Conclusion

Throughout this study, our primary goal was to understand the intricate relationship between wildfire smoke exposure and respiratory health, particularly in the context of Grand Junction, Colorado, employing a human-centered data science approach. Our research aimed to answer critical questions regarding the impact of wildfire smoke on respiratory diseases and its implications for the local community.

By analyzing historical wildfire data and correlating it with Air Quality Index (AQI) measurements, we aimed to quantify the influence of smoke exposure on health outcomes. Moreover, our investigation delved into the mortality rates associated with various chronic respiratory diseases, highlighting potential correlations with estimated smoke impacts.

Our findings underscore several crucial insights. We observed a substantial increase in both the frequency and proximity of wildfires over time, signifying a heightened risk of smoke exposure for the community. Moreover, the rise in smoke estimates and AQI levels aligns with concerning escalations in respiratory disease mortality rates, specifically interstitial lung disease, pulmonary sarcoidosis, and chronic respiratory diseases, highlighting the impact of wildfire smoke on public health.

This study contributes significantly to the understanding of human-centered data science by demonstrating the complexity of analyzing environmental data's human health implications. It emphasizes the multidimensional nature of factors influencing health outcomes, such as meteorological conditions, geographical features, demographic variations, and data quality considerations.

Understanding the nuances of data analysis, interpretation, and communication in the context of human health and environmental impact is crucial. This study prompts a reevaluation of methodologies and approaches in human-centered data science, highlighting the need for interdisciplinary collaboration, ethical considerations, community engagement, and transparent communication in analyzing and interpreting health-related data.

Moving forward, this study serves as a stepping-stone towards fostering greater awareness, guiding public health interventions, and inspiring further research aimed at mitigating the adverse effects of wildfire smoke on respiratory health within communities. As we navigate the complexities of data-driven analyses in human-centered contexts, our study underscores the imperative of employing a holistic and ethical approach to address pressing health concerns while leveraging the power of data science for societal well-being.

References

A. Figures:

- *Figure 1:* https://www.cpr.org/2020/08/02/wildfire-in-mesa-county-that-began-friday-climbs-to-1020-acres-by-sunday/
- *Figure 2:* https://www.mesacounty.us/departments-and-services/sheriff/divisions/emergency-services/wildland-fire-management/after/health

B. Papers used for support in the Background section of the report:

- Westerling, A. L., Hidalgo, H. G., Cayan, D. R., & Swetnam, T. W. (2006). Warming and earlier spring increase western US forest wildfire activity. Science, 313(5789), 940-943.
- Liu, Y., Stanturf, J., & Goodrick, S. (2010). Trends in global wildfire potential in a changing climate. Forest ecology and management, 259(4), 685-697.
- Pfister, G. G., Wiedinmyer, C., & Emmons, L. K. (2008). Impacts of the fall 2007 California wildfires on surface ozone: Integrating local observations with global model simulations. Geophysical Research Letters, 35(19).
- Wegesser, T. C., Pinkerton, K. E., & Last, J. A. (2009). California wildfires of 2008: coarse and fine particulate matter toxicity. Environmental health perspectives, 117(6), 893-897.
- Phuleria, H. C., Fine, P. M., Zhu, Y., & Sioutas, C. (2005). Air quality impacts of the October 2003 southern California wildfires. Journal of Geophysical Research: Atmospheres, 110(D7).
- Reid, C.E., Brauer, M., Johnston, F.H., Jerrett, M., Balmes, J.R. and Elliott, C.T., 2016. Critical review of health impacts of wildfire smoke exposure. Environmental health perspectives, 124(9), p.1334-1343.
- Emmanuel, S.C., 2000. Impact to lung health of haze from forest fires: the Singapore experience. Respirology, 5(2), pp.175-182.

- Johnston, F.H., Webby, R.J., Pilotto, L.S., Bailie, R.S., Parry, D.L. and Halpin, S.J., 2007. Vegetation fires, particulate air pollution and asthma: A panel study in the Australian monsoon tropics. International journal of environmental health research, 17(6), pp.391-404.

C. Wildfire Dataset Metadata:

NAME	DTYPE	DESCRIPTION
OBJECTID	Integer	Unique identification for the polygon and it's attributes
USGS_Assigned_ID	Integer	Assigned unique identification for the polygon and it's attributes. Used to provide consistency if parts of the dataset are exported or the OBJECTID is otherwise changed
Assigned_Fire_Type	String	Based on the fire polygon(s) used to create this fire feature what is the type assigned to this fire? If more than one type was assigned to a combined polygon, the assigned fire type was assigned in the following order of dominance: Wildfire, Likely Wildfire, Unknown - Likely Wildfire, Prescribed Fire, Unknown - Likely Prescribed Fire
Fire_Year	Integer	The calendar year when the dataset creators determined the fire occurred
Fire_Polygon_Tier	Integer	The tier from which the fire polygon was generated. One or more polygons within the tier could be combined to create the fire polygon
Fire_Attribute_Tiers	String	All fire tiers that contributed attributes to the fire feature. A list of all tiers where a polygon intersects the current fire perimeter in space and time
GIS_Acres	Float	The GIS calculated acres of the fire polygon calculated by using the Calculate Geometry tool in ArcGIS Pro
GIS_Hectares	Float	The GIS calculated hectares of the fire polygon calculated by using the Calculate Geometry tool in ArcGIS Pro
Source_Datasets	String	All of the original source datasets that contributed to either the polygon or the attributes. Each dataset has the number of polygons contributed listed in parentheses after the dataset name
Listed_Fire_Types	String	Each fire type listed in the fires from the merged dataset that intersect this polygon in space and year. The number of features that contributed the specific fire type are in parentheses after the fire type
Listed_Fire_Names	String	Each fire name listed in the fires from the merged dataset that intersect this polygon in space and year. The number of features that contributed the specific fire name are in parentheses after the fire name
Listed_Fire_Codes	String	Each fire code listed in the fires from the merged dataset that intersect this polygon in space and year. The number of features that contributed the specific fire code are in parentheses after the fire code
Listed_Fire_IDs	String	Each fire type listed in the IDs from the merged dataset that intersect this polygon in space and year. The number of features that contributed the specific fire ID are in parentheses after the fire ID
Listed_Fire_IRWIN_IDs	String	Each fire IRWIN ID listed in the fires from the merged dataset that intersect this polygon in space and year. The number of features that contributed the specific fire IRWIN ID are in parentheses after the fire IRWIN ID
Listed_Fire_Dates	String	Each fire date listed in the fires from the merged dataset that intersect this polygon in space and year. The number of features that contributed the specific fire date are in parentheses after the fire date
Listed_Fire_Causes	String	Each fire cause listed in the fires from the merged dataset that intersect this polygon in space and year. The number of features that contributed the specific fire cause are in parentheses after the fire cause
Listed_Fire_Cause_Class	String	Each fire cause class listed in the fires from the merged dataset that intersect this polygon in space and year. The number of features that contributed the specific fire cause class are in parentheses after the fire cause class

FIGURE 14: USGS DATASET PART 1

Listed_Rx_Reported_Acres	String	Each prescribed fire reported acres listed in the fires from the merged dataset that intersect this polygon in space and year. The number of features that contributed the specific reported acres are in parentheses after the reported acres
Listed_Map_Digitize_Methods	String	Each fire digitization method listed in the fires from the merged dataset that intersect this polygon in space and year. The number of features that contributed the specific fire digitization method are in parentheses after the fire digitization method
Listed_Notes	String	Each fire notes listed in the fires from the merged dataset that intersect this polygon in space and year. The number of features that contributed the specific fire notes are in parentheses after the fire note
Processing_Notes	String	Indicates that the attribute data were altered during the processing and a new attribute was indicated. It will also explain the rationale for the change. Each polygon that had an attribute changed will be listed along with a count, in parentheses indicating how many polygons had the change made to them
Wildfire_Notice	String	A notice present in every field that indicates the quality of the wildfire data in this dataset
Prescribed_Burn_Notice	String	A notice present in every field that indicates the quality of the prescribed burn data in this dataset
Wildfire_and_Rx_Flag	String	A text flag field indicating that the attributes from the various sources indicate that the fire was both a wildfire and a prescribed fire. This could indicate an error in assigning the fire type, a misassignment of the fire type, or that there were actually two fires that occurred in this area in the same year, one a wildfire and one a prescribed burn
Overlap_Within_1_or_2_Flag	String	An ArcGIS Tabulate Intersection Tool was used to identify areas that burned with >10% overlap of the current fire within 1 or 2 years of the current burn. Each fire that met that criteria was included in this attribute including it's ID, year burned, percent overlap, and acres
Circleness_Scale	Float	A measure of a polygon's similarity to a true circle. calculated using the Shape_Length and Shape_Area fields. Circle-ness = 4*pi*(Shape_Area/(Shape_Length * Shape_Length)). As the number approaches 1, the polygon becomes more circular
Circle_Flag	String	Any Circle circle-ness values >=0.98 are flagged with a 1. The remaining values are null. 1 indicates that the polygon is very circle-like and is likely incorrect. However, other values that are not flagged may still be quite circular and incorrect
Exclude_From_Summary_Rasters	String	Some fires in this dataset appear to be buffered circles. These were kept in the dataset to show location and approximate area. However a decision was made to exclude circular fires larger than 1 acre in size from the summary raster calculations. This field indicates whether the fire was excluded from ('Yes') or included in ('No') the summary raster calculations
Shape_Length	Float	Automatically calculated perimeter length in meters
Shape_Area	Float	Automatically calculated polygon area in square meters

FIGURE 15: USGS DATASET PART 2

D. GitHub Repo:

a. Link

E. AQS API: Air Quality System (AQS) API

Data Sources

1. **USGS Wildland Fire Combined Dataset [link]:** A trove of information meticulously collected and aggregated by the US Geological Survey. The dataset, available in both ArcGIS and GeoJSON formats, unveils the contours of fire polygons with comprehensive documentation. The metadata can be viewed in the reference section in Figures 14 and 15.
2. **US EPA Air Quality System API [link]:** A nationwide repository of air sample data, encompassing meteorological insights and AQI values for diverse pollutants from an array of monitoring stations. This dataset, accessed via an API from the EPA's Air Quality System database, contains historical and present Air Quality Index (AQI) measurements across the U.S. The AQI, ranging from 0 to 500, covers ground-level ozone, particle pollution, carbon monoxide, sulfur dioxide, and nitrogen dioxide levels. Focusing on AQI readings from Mesa County during fire seasons, this dataset is pivotal for correlating smoke estimates with actual air quality and potential health impacts. Usage guidelines and terms are available on the dataset's website listed above.
3. **Respiratory Disease Mortalities in the United States (1980-2014) [link]:** This dataset, available in CSV format from the Institute for Health Metrics and Evaluation (IHME) website, chronicles mortalities caused by respiratory diseases in the United States. Maintained and hosted by IHME, it covers mortality data from 1980 to 2014 across all counties in the USA. The dataset offers comprehensive information on causes, years, sexes, and estimates such as posterior mean, 2.5th percentile, and 97.5th percentile estimates. It specifically outlines age-standardized mortality rates (deaths per 100,000 population) among various sexes and for the combined sexes for the years 1980-2014 across all counties. Included in this dataset are both string-based descriptors (measure_name, location_name, cause_name, sex, age_name, metric) and integer-based identifiers (measure_id, location_id, FIPS, cause_id, sex_id, age_id, year_id, mx, lower, upper). Importantly, the dataset is devoid of any null values across all columns, ensuring clean and comprehensive data. The dataset description can be referenced from Figure 3.