Impact of Wildfires on Community Health in Grand Forks

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1. Introduction/Motivation

This is an analysis of wildfires and how the smoke from wildfires affects the cities near them. This analysis focuses specifically on Grand Forks, North Dakota. Grand Forks is the third most populous county in the state of North Dakota, USA. This analysis aims to understand how wildfires impact the community health of Grand Forks.

This report is the fourth and the final deliverable of a 4-part project that was undertaken during the DATA 512 coursework. The four sections of the project are as follows.
Part 1- Pulling data from different sources and calculating the smoke estimate
Part 2- Creating the Extension Plan to conduct further research
Part 3- Presenting the results in a presentation
Part 4- Creating the final report and repository

This project's primary source of inspiration is the increasing frequency with which summers in the western United States have been marked by wildfires that send smoke billowing across many western states. Numerous factors have been suggested as the reason for this, including rising awareness, US Forestry policy, and climate change. Wildland fires have a broad impact, regardless of the cause. Wildfire damage has the potential to seriously affect human settlements as well as the environment.
The impacts are multifaceted and can include:

1. **Loss of Human Lives**
   Wildfires can directly endanger human safety and result in fatalities as well as injuries. Additionally risky are firefighting operations and evacuations.
2. **Property Damage**
   Structures, including residences, can be completely destroyed by wildfires. Both people and communities suffer significant financial losses as a consequence of this.
3. **Air Quality Issues**
   Wide-spread air quality is impacted by wildfires because they send copious volumes of smoke and particulate matter into the atmosphere. This may worsen pre-existing medical ailments and cause breathing issues.
4. **Disruption of Services**
   Wildfires can cause extra difficulties for impacted areas by interfering with vital services including communication networks, transportation, and electricity supplies.

The research on the impact of wildfires on healthcare resources in Grand Forks addresses a real and pressing issue. Wildfires, with their increasing frequency and intensity, have far-reaching consequences on communities, and the effects on public health are a critical aspect. The analysis of the correlation between wildfires, increased smoke levels, declining air quality, and the subsequent strain on healthcare resources provides relevant and valuable insights.
Examining how wildfires affect the availability of hospital beds and increase hospital revenues sheds light on the tangible consequences that these natural disasters have on the local healthcare system. This type of research is essential for policymakers, healthcare professionals, and emergency responders to better understand the challenges they may face in managing healthcare services during and after wildfire events.

2. Background / Related Work

In the exploration of issues arising from wildfires and their impact on the healthcare facilities of a specific city, three informative write-ups were discovered:

1. How Wildfires Affect Health by the American Lung Association: This source delves into various ways wildfires affect health, with a focus on the respiratory and cardiovascular repercussions of wildfire smoke.
2. Research Brief on Wildfires by the Washington State Office of Financial Management: This research brief offers in-depth insights into the economic consequences of wildfires, including their effects on healthcare costs and labor productivity.
3. Health Effects Attributed to Wildfire Smoke by the U.S. Environmental Protection Agency (EPA): The EPA's course sheds light on the pollutants present in wildfire smoke and their specific health implications.

Collectively, these resources contribute to a comprehensive understanding of the multifaceted challenges posed by wildfires, addressing both immediate health concerns and broader socio-economic aspects. These pieces aided in gaining insights into how people are affected by this natural calamity and the ongoing efforts to address the issue. Subsequently, research questions were formulated for further exploration in this field:

1. Are most of the fires in a 1250-mile radius near Grand Forks or farther away from the county?
2. What is the impact on the number of reported cases of respiratory diseases due to the increase in wildfires in Grand Forks?
3. What kind of impact does wildfire have on the fatality rate of Grand Forks county?

To address these questions, a metric called the Smoke Estimate was devised, intending to mimic the trend of the general Air Quality Index (AQI) of the city. Further details about the logic and calculation of the smoke estimate will be discussed in the next section.

Following the computation of the smoke estimate, an extension plan was submitted, outlining the future direction of the research. The goal is to provide suggestions to Grand Forks' city council on issues faced by citizens due to increasing smoke from wildfires, including rising costs and decreasing availability of healthcare.

The extension plan involves incorporating an additional dataset into the analysis to make it more human-centered and to understand the direct impacts of wildfires on the human population. A brief data profile of the dataset and its source is provided below.

Data Profile
Name:
United States Chronic Respiratory Disease Mortality Rates by County 1980-2014
Link:
https://ghdx.healthdata.org/record/ihme-data/united-states-chronic-respiratory-disease-mortality-rates-county-1980-2014
Summary:
IHME research produced estimates for age-standardized mortality rates by county from chronic respiratory diseases. The estimates were generated using de-identified death records from the National Center for Health Statistics (NCHS); population counts from the U.S. Census Bureau, NCHS, and the Human Mortality Database; the cause list from the Global Burden of Disease Study (GBD); and the application of small area estimation models. This dataset provides estimates for age-standardized mortality rates by disease type and sex at the county level for each state, the District of Columbia, and the United States as a whole for 1980-2014, as well as the changes in rates for each location during this period. Also included are data on the 10 counties with the highest and lowest mortality rates for each disease type in 2014.
License:
Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License
Fields:

1. measure_name: The measure (indicator) of the estimate
2. location_ID: Unique numeric identifier for the location generated and stored in an IHME database of data dimensions
3. location_name: Location of the estimate
4. FIPS: The Federal Information Processing Standards (FIPS) code, a unique identifier for states and counties in the United States

5. cause_id: Unique numeric identifier for the cause of disease or injury generated and stored in an IHME database of data dimensions
6. cause_name:Cause of disease or injury of the estimate
7. sex_ID: Unique numeric identifier for the sex generated and stored in an IHME database of data dimensions
8. sex_name: Gender for the estimate
9. year_ID: Time period of estimate metric Metric Metric/unit of measure for the estimate
10. age_group_ID: Unique numeric identifier for the age group generated and stored in an IHME database of data dimensions
11. age_group_name: Age group estimated

3. Methodology

This study commenced by extracting wildfire data from a geojson file dataset collected and aggregated by the US Geological Survey. The dataset encompasses fire polygons representing wildfires that occurred across the USA. The file is accessible here.

The data headers are as follows:

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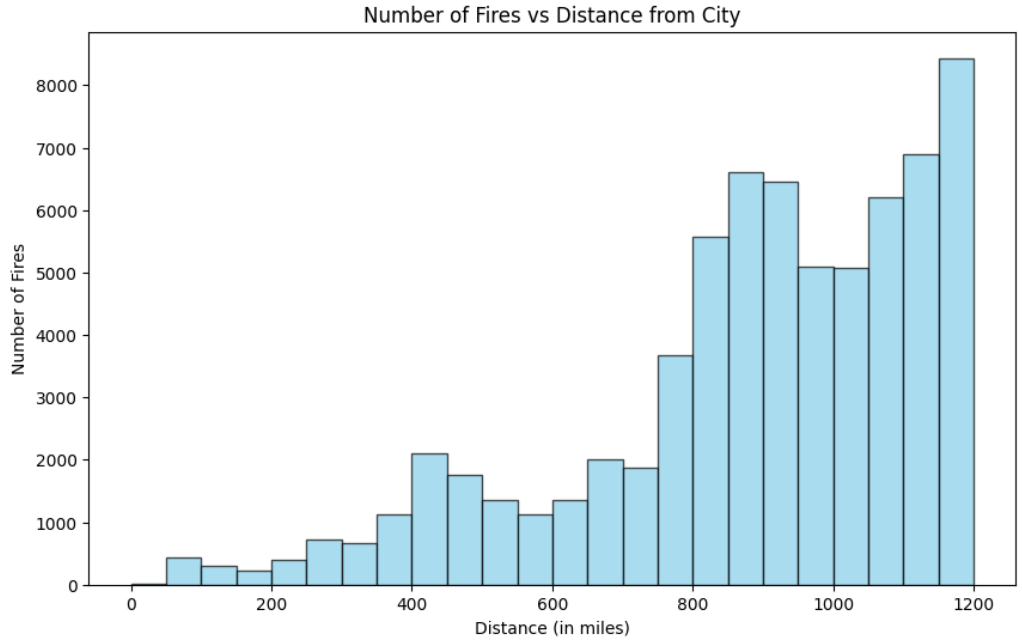
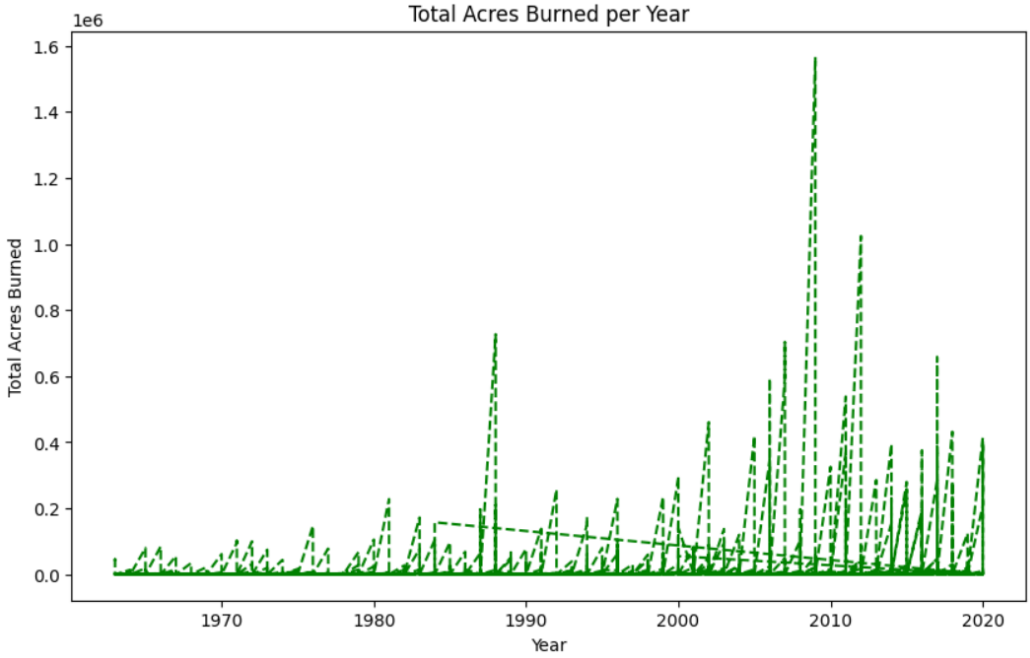
{
    "displayFieldName": "",
    "fieldAliases": {
        "OBJECTID": "OBJECTID",
        "USGS_Assigned_ID": "USGS Assigned ID",
        "Assigned_Fire_Type": "Assigned Fire Type",
        "Fire_Year": "Fire Year",
        "Fire_Polygon_Tier": "Fire Polygon Tier",
        "Fire_Attribute_Tiers": "Fire Attribute Tiers",
        "GIS_Acres": "GIS_Acres",
        "GIS_Hectares": "GIS_Hectares",
        "Source_Datasets": "Source Datasets",
        "Listed_Fire_Types": "Listed Fire Types",
        "Listed_Fire_Names": "Listed Fire Names",
        "Listed_Fire_Codes": "Listed Fire Codes",
        "Listed_Fire_IDs": "Listed Fire IDs",
        "Listed_Fire_IRWIN_IDs": "Listed Fire IRWIN IDs",
        "Listed_Fire_Dates": "Listed Fire Dates",
        "Listed_Fire_Causes": "Listed Fire Causes",
...
            "alias": "Shape_Area"
        }
    ]
}
```

The study began by extracting wildfire data from a geojson file dataset collected and aggregated by the US Geological Survey. This dataset includes fire polygons representing wildfires that occurred across the USA, and the file can be accessed here.

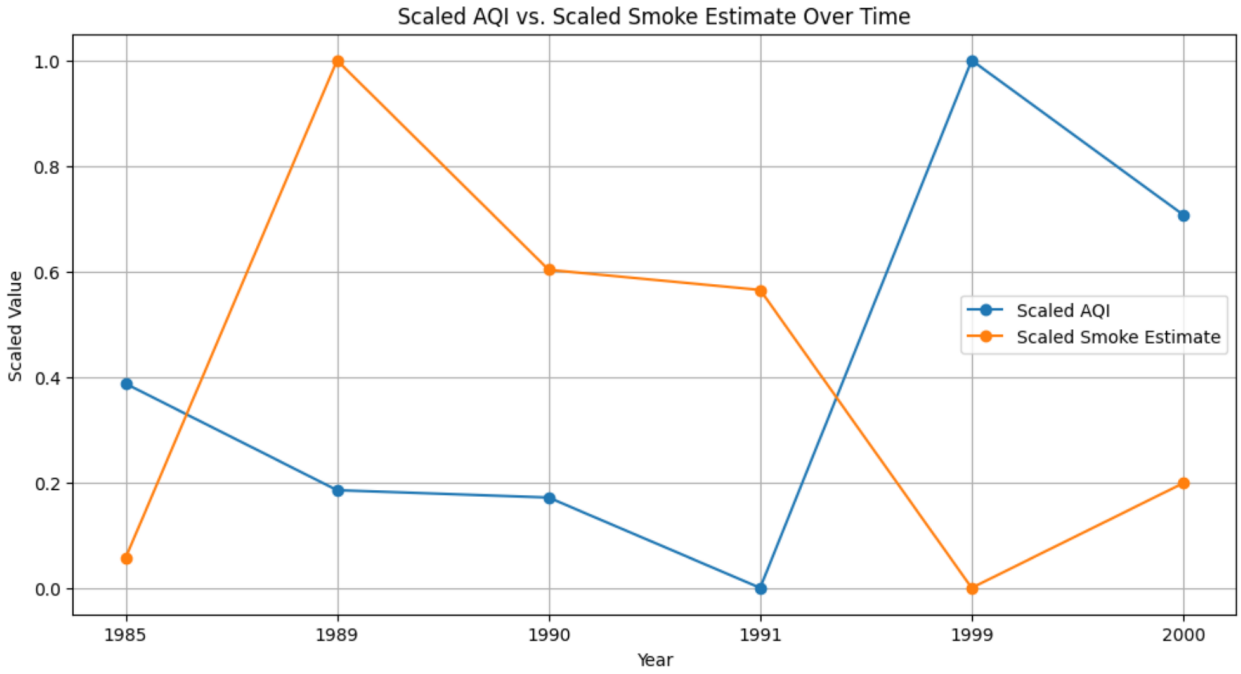
Subsequently, the data was filtered for the city of Grand Forks, focusing on wildfires within a 1250-mile radius from the city. The following graph depicts the number of wildfires within this specified area:



The total burnt area in acres per year is shown below:



As a next step in the data analysis, correlation coefficient between air quality index and smoke estimate was calculated. The below graph shows the relationship between the aforementioned metrics.



Forecasting smoke levels over 25 years

In this phase of the study, an advanced forecasting technique is employed to predict the future smoke levels in Grand Fork county over the next quarter-century. The methodology involves utilizing historical records of smoke levels and employing them to estimate future quantities.

Getting Data Ready:

Past smoke data is organized into a structured table using two common data-handling tools, NumPy and Pandas. The column containing years is converted into dates for proper analysis.

Using Prophet for Forecasting:

The Prophet tool is configured to account for weekly changes. It leverages historical data to identify regular patterns and shifts in smoke levels.

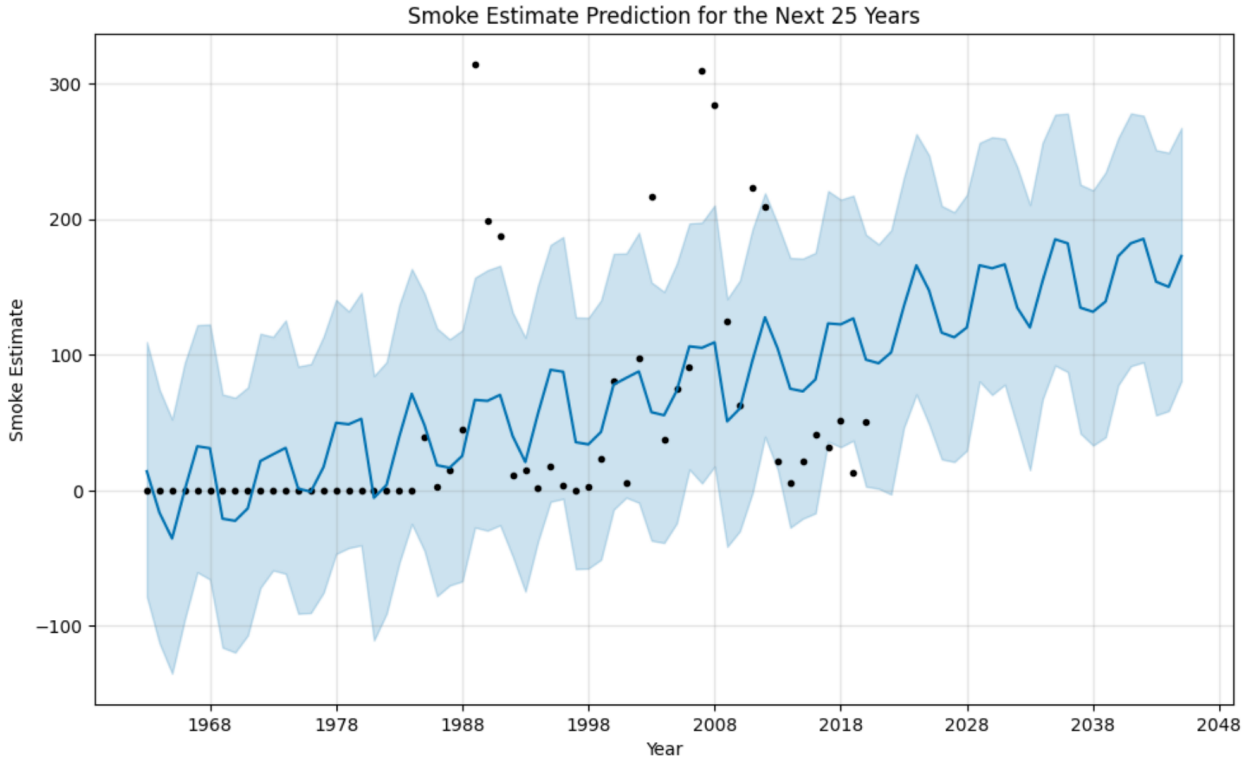
Making Future Forecasts:

A new table is generated to display smoke predictions for the next 25 years. Utilizing Prophet, calculations are performed to project the potential smoke levels in the upcoming years.

Drawing the Predictions:

A chart depicting predicted smoke levels is created to visually represent potential trends and shifts in smoke levels in Grand Fork county over the specified time frame. This

chart serves as a valuable tool for understanding future scenarios related to smoke levels.



In pursuit of the objectives outlined in the extension plan, the analysis delved into healthcare data versus the smoke estimate. The selection of detailed county and hospital-specific data was driven by the need for a human-centered approach. The Data Sheet, encompassing various aspects of hospitals nationwide, served as a valuable resource. Extracting county and hospital-specific details from this sheet offered insights into healthcare utilization, financial trends, and the impacts of specific services, providing direction to the project.

To enhance the granularity and applicability of healthcare data from the Oregon Health Authority's Hospital Reporting, the analysis focused specifically on Klamath County. Transforming hospital-related metrics into a year-wise format, the examination aimed to provide a comprehensive understanding of annual variations in healthcare indicators, particularly within the local context of Grand Forks. This targeted approach established a direct correlation with the year-wise smoke estimate time series data generated in the project's initial phase. A comparison between yearly healthcare metrics for Grand Forks and corresponding smoke impact estimates offers nuanced insights into potential relationships between wildfire smoke exposure and healthcare outcomes in the region.

The human-centered aspects of this study, including ethical considerations, play a pivotal role:

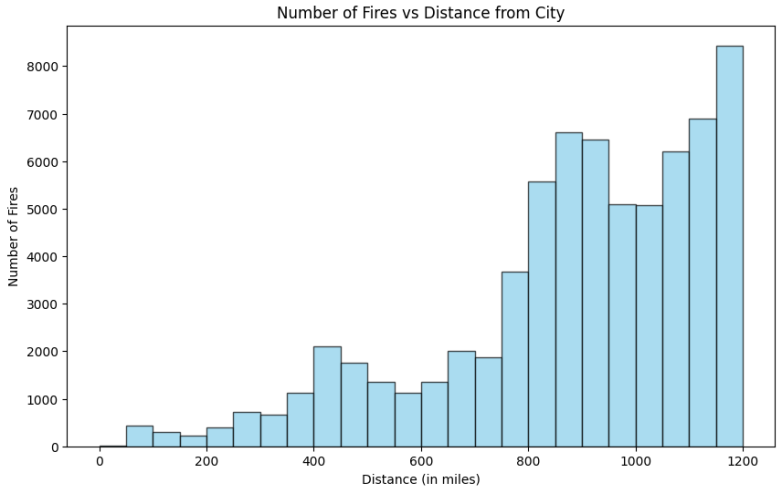
1. Ethical Data Usage:
   Personal data was not utilized, and only publicly available data was used. Proper acknowledgment and inclusion of licenses were ensured.
2. Healthcare Information:
   The healthcare information used is aggregated and does not point towards any specific individual, ensuring data privacy.
3. Transparency and Communication:
   Study objectives, methodologies, and potential implications were communicated transparently. Clear and accessible information about the study's purpose and findings was provided to the public.

By addressing these ethical considerations, the study on wildfires in Grand Forks not only contributes valuable scientific insights but also respects the rights, well-being, and perspectives of the individuals and communities involved. This human-centered approach enhances the credibility and social responsibility of the research.

To calculate the impact of wildfire smoke on the number of reported fatalities due to various underlying conditions, data from the Wonder database provided by the Center for the Disease Control (CDC) was used to perform various aggregations and filtering relevant to Grand Forks county. To calculate the growth of respiratory diseases over the last 50 years in Grand Forks and compare it to the prevalence of smoking in the county, data released by the Institute for Health Metrics and Evaluation (IMHE) was analyzed.

4. Findings

First, to address the first research question, "Are most of the fires in a 1250-mile radius near Grand Forks or farther away from the city," a graph was plotted, illustrating the distribution of fires within the specified 1250-mile radius from Grand Forks.



The graph provides a visual representation, allowing for an immediate assessment of the geographic proximity of the fires to the city. From the graph above, it seems that

Grand Forks is not vulnerable to wildfires as a hazard since most cases of wildfires occur hundreds of miles away from the county. However, this does not mean that the county is actually safe from wildfires. This report from the Washington Post suggests that although Grand Fork county and the North Dakota state at large are safe from the wildfires, the neighboring states such as South Dakota, Wyoming, and Montana are very much vulnerable to it. Due to this, Grand Forks is vulnerable to the hazardous smoke generated by the wildfires in these neighboring states. Similarly, there have been increases in the cases of wildfire smoke from Canada traveling to North Dakota and Grand Forks due to the directions of wind currents.

Next, in order to understand the impact on the number of reported cases of respiratory diseases due to the increase in wildfires in Grand Forks, the United States Chronic Respiratory Disease Mortality Rates by County 1980-2014 dataset released by the IHME was analyzed. United States Smoking Prevalence by County 1996-2012 dataset was also analyzed to account for smoking as a potential contributor to the rising number of cases of respiratory diseases.

TRACHEAL, BRONCHUS, AND LUNG CANCER

Sex	Grand Forks County	North Dakota	National	National rank	% change 1980-2014
Female	46.8	38.2	43.8	1465	+72.6
Male	68.7	61.5	67.6	1149	-9.4

rate per 100,000 population, age-standardized, 2014

In the above table, it can be seen that the number of cases of respiratory diseases increases by about 72% in females from 1980 to 2014. However, analyzing the smoking data from the same time period highlights that although the cases of respiratory diseases were on the rise in Grand Forks, smoking was on a decline during the same period of time. Because smoking has been on a decline, it's difficult to attribute the rising cases of respiratory diseases to it.

SMOKING

Sex	Grand Forks County	North Dakota	National	National rank	% change 1996-2012
Female	17.1	20.0	17.9	409	-23.5
Male	22.0	23.4	22.2	582	-15.6

prevalence (%), age-standardized, 2012

Lastly, to address the research question "What kind of impact does wildfire have on the fatality rate of Grand Forks county?" data from the Wonder database released by the CDC was analyzed after filtering for Grand Forks county. After initial analysis, it was found that more than 48% of all the fatalities in Grand Forks in the year 2015 were due to cancer, respiratory diseases, and stroke. This research released in the Journal of the

American Heart Association lists cancer, respiratory diseases, and stroke as high-risk symptoms arising due to the long exposure to wildfire smoke.

15 Leading Causes of Death	Deaths
#Malignant neoplasms (C00-C97)	109
#Diseases of heart (I00-I09,I11,I13,I20-I51)	82
#Chronic lower respiratory diseases (J40-J47)	29
#Alzheimer disease (G30)	28
#Accidents (unintentional injuries) (V01-X59,Y85-Y86)	28
#Cerebrovascular diseases (I60-I69)	23
#Septicemia (A40-A41)	12
#Diabetes mellitus (E10-E14)	12
#Intentional self-harm (suicide) (*U03,X60-X84,Y87.0)	10

In this way, data from various sources was utilized to research about the questions and come to a conclusion.

5. Discussion and Implications

Importance of findings

The findings of the wildfire project hold paramount importance due to their direct implications on public health, particularly in the context of the Grand Forks county. By establishing a correlation between the frequency of wildfires and an increase in reported cases of respiratory diseases, the study underscores the urgent need for proactive measures. The use of a smoke estimate as a proxy for air quality impact adds a novel dimension, emphasizing the broader health consequences of prolonged exposure to wildfire-related pollutants. These findings shed light on the multifaceted challenges faced by the community beyond immediate fire-related injuries, reinforcing the necessity for comprehensive disaster preparedness and response strategies.

Recommendations for the City Council

1. Implement early warning systems to notify residents about wildfires in neighboring areas.
    a. Leverage advanced technologies like satellite monitoring and data analytics to enhance the effectiveness of early warning systems.
    b. Establish accessible communication channels, including mobile apps and community outreach, and conduct regular drills to ensure residents are well-informed and prepared.

2. Designate community safe spaces with high-quality air filtration systems.
    a. Identify strategic locations as safe spaces during wildfires, ensuring they have high-quality air filtration systems.

    b. Collaborate with community organizations to expand the network of safe spaces, providing refuge with clean air for residents.
3. Support vulnerable populations in their personal space by distributing air purifiers and masks during wildfire events.
    a. Develop targeted outreach programs to assist vulnerable populations in acquiring air purifiers and masks.
    b. Establish distribution centers and provide educational resources on proper usage to reduce health risks during wildfires.
4. Chalk-out emergency response plan in collaboration with local health services and emergency management agencies.
    a. Collaborate with local health services and emergency management agencies to create a detailed emergency response plan.
    b. Conduct regular training sessions to test and improve the plan's effectiveness, ensuring coordinated actions during wildfire events.
5. Implement stricter “burn-ban” policies.
    a. Review and strengthen burn-ban policies considering weather conditions and historical wildfire patterns.
    b. Increase public awareness through campaigns and collaborate with law enforcement for stricter enforcement and penalties to prevent wildfires.

Schedule for Concrete Designs

It is imperative that the city council, city manager/mayor, and inhabitants take immediate action in light of the growing frequency of wildfires and their possible impact on public health. Within the following six to twelve months, a clear plan should be developed in order to give ample time for the creation of a thorough strategy, the mobilization of resources, and public awareness campaigns. By putting these plans into action quickly, the city will become more resilient and the safety of its citizens will be protected from the growing threat of wildfires.

6. Limitations

a. **The availability of a high-quality dataset:** Additional information for the research expansion was sourced from the internet. The data, reported by the North Dakota government, though available, is subject to debate regarding its veracity. The inclusion of a few supplementary data points could potentially enhance the accuracy of the prediction model.
b. **Accuracy of smoke estimate**: The smoke estimate was generated based on the limited information provided in the preceding section. Specifically, the concentrations of several primary air pollutants, each weighted to represent its potential impact on health, form the foundation for the analysis of Air Quality

Index (AQI) values. Ground-level ozone (O3), particulate matter (PM10 and PM2.5), carbon monoxide (CO), sulfur dioxide (SO2), and nitrogen dioxide (NO2) are common pollutants considered in the calculation of AQI.

c. **Unavailability of data**: One of the factors that could have contributed to the increase in respiratory diseases is increase in air pollution due to vehicular traffic. However, there was no dataset found in the initial search that could have been used for further analysis.
d. **Assuming Autocorrelation**: Since we are utilizing an autoregressive model to forecast the amount of smoke for the next 25 years, we are making the assumption that the data from earlier time steps will be helpful in forecasting the amount of smoke for the future. This may not be true since a lot of wildfires occur due to accidents and unforeseen natural and manmade conditions.
e. **Additional elements influencing the healthcare system**: In the course of researching wildfire smoke, the focus has been on understanding its contributions to the various consequences discussed in the paper. However, it is important to acknowledge that several additional factors may directly impact the study topics. For example, a general increase in healthcare costs could be a contributing factor to the rise in hospital income, and this is not exclusive to the effects of wildfires.

7. Conclusion

Research Questions

1. Are most of the fires in a 1250-mile radius near Grand Forks or farther away from the county?
2. What is the impact on the number of reported cases of respiratory diseases due to the increase in wildfires in Grand Forks?
3. What kind of impact does wildfire have on the fatality rate of Grand Forks county?

Summary of Findings

1. Majority of the cases of wildfires were much farther away from Grand Forks county. This means that the county is safe from the wildfire. However, the same cannot be said about the wildfire smoke. The county remains vulnerable to the smoke due to the wildfires in South Dakota, Montana, Wyoming, and Canada.
2. The number of reported cases of respiratory diseases is on the rise in Grand Forks. During the same time period, the prevalence of smoking has reduced. So, the increase in respiratory diseases can be attributed to the increasing wildfire smoke.

3. About 48% of all the fatalities in Grand Fork in the year 2015 were due to some form of respiratory diseases, lung cancer, and stroke. These diseases are also the common denominators in the wildfire smoke.

Informing Human Centered Data Science

This research contributes to the field of human-centered data science by providing concrete examples of how natural catastrophes affect regional healthcare systems. The results highlight the significance of including human-focused factors in data science models, such as the influence of air quality and the availability of healthcare resources. By doing this, data scientists may support more comprehensive and adaptable strategies, guaranteeing that data-driven solutions take into account the practical difficulties that communities encounter both during and after natural disasters. This study provides a useful illustration of how human-centered data science may enhance emergency response plans, support resilience in the face of environmental difficulties, and influence decision-making procedures.

8. References

1. https://www.washingtonpost.com/climate-environment/interactive/2022/wildfire-risk-map-us/
2. https://www.healthdata.org/sites/default/files/files/county_profiles/US/2015/County_Report_Grand_Forks_County_North_Dakota.pdf
3. https://www.ahajournals.org/doi/10.1161/JAHA.117.007492
4. https://creativecommons.org/licenses/by-nc-nd/4.0/

9. Data Sources

1. A geojson file dataset collected and aggregated by the US Geological Survey. This contains fire polygons for wildfires that have occurred across the USA. The file can be found here: https://www.sciencebase.gov/catalog/item/61aa537dd34eb622f699df81
2. An API accessing sample notebook to obtain the Air Quality Estimates for regions in the USA: https://drive.google.com/file/d/1bxl9qrb_52RocKNGfbZ5znHVqFDMkUzf/view?usp=sharing
3. A spreadsheet listing the assignments of different cities: https://docs.google.com/spreadsheets/d/1cmTW5fgU3KyH6JbrRao-qWjzu2GovKk_BkA7a-poGFw/edit#gid=1247370552
4. United States Smoking Prevalence by County 1996-2012: https://ghdx.healthdata.org/record/ihme-data/united-states-smoking-prevalence-county-1996-2012

5. United States Chronic Respiratory Disease Mortality Rates by County 1980-2014: https://ghdx.healthdata.org/record/ihme-data/united-states-chronic-respiratory-disease-mortality-rates-county-1980-2014
6. About Underlying Cause of Death, 1999-2020: https://wonder.cdc.gov/ucd-icd10.html