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Effect of Climate Change on Lung Cancer

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Abstract

This research paper aims to draw a relationship between lung cancer and climate change. With the rise of climate change in the last few decades, many organizations and people are concerned about the future of the world. Climate change has many side effects, such as air pollution, which can increase the incidence and death rates of lung and bronchus cancer. This paper aims to draw the relationship between climate change factors and lung cancer incidence and mortality rates. The main finding of this analysis was that there is a positive relationship between lung cancer incidence, death rates, and climate change indicators. The findings from this study have the potential to inform targeted public health interventions and policies, emphasizing the need for proactive strategies in mitigating the health impacts of a changing climate. Section 2 of this paper is a literature review and focuses on the findings of other scholars in this field. Section 3 of this paper is Methods and Processes and will highlight the steps used to create the program and get the results. Section 4 of this paper is Results and Analysis, and will go over the results produced by the machine learning algorithm, and will present graphs and visualizations regarding the relationship of the dependent and independent variables. The final section, Section 5, is Limitations and Conclusion, in which we will discuss possible limitations to both my dataset and my model, and will conclude the paper by presenting a big-picture view of these problems in our society.

Keywords

Cancer, Lung Cancer, Climate Change

1. Introduction

Climate change is at the forefront of global issues. The combined land and ocean temperature has increased at an average rate of 0.14 degrees Fahrenheit (0.08 degrees Celsius) per decade since 1880 [1]. Climate change is the long-term shift of weather patterns and temperature (United Nations, 2005). Climate change is

occurring faster than ever nowadays, and the rate of temperature increase since 1981 is over double the rate of the increase of the temperature in 1881 [2]. These changes are often seen as irreversible, and if drastic measures are not taken, the world could be destroyed for future generations. Even though climate change is primarily an increase in temperature and harsh weather conditions, it has a myriad of tendrilous side effects that can affect many other things. For example, climate change can lead to excess oxygen buildup in water and increase its solubility. The excess oxygen can lead to the eutrophication of water and can promote harmful algae growth. This alga can contaminate the water and can encourage the spread of disease to those who come into contact with it. Additionally, the increased level of storms such as gales and tornadoes can accelerate the propagation of airborne particles which can linger in the atmosphere and damage the health of those who are in its proximity. Climate change is a huge topic of modern research, and a lot of efforts are being made to quell it, by both organizations and the general public.

While climate change is the main topic of discussion for international environmental organizations, Cancer is the main topic of discussion for many medical organizations around the globe. Cancer is one of the deadliest diseases and is one of the few diseases in our modern world that is deemed incurable by modern medicine. Cancer, along with being highly fatal, is extremely common in the United States. Over the past few decades, the probability of getting cancer in both men and women has skyrocketed. Men have a 1 in 2 chance of being diagnosed with cancer in their lifetime; for women, that statistic is 1 in 3 [2]. The prevalence of cancer in modern society and its incurable status has frightened many medical professionals and cancer research institutes around the world. However, many universities such as the Sidney Kimmel Cancer Center at John Hopkins University have made many important discoveries in the field, such as the discovery of the inflammasome [3].

Now, although it may not seem that there is a relationship between these two issues, there is a glaring connection between the two. Storms such as hurricanes and tornadoes that are brought on by climate change can accelerate the spread of airborne particles. These particles can cause damage to the lungs, especially smaller particles, which can get lodged in the walls of lung cells and cause serious inflammation. This inflammation can cause difficulty in breathing and can lead to malignant tumor growth in the lungs. This connection with air pollution piqued my interest, and I did a bit more research and collected data about some of the other effects of climate change, such as water pollution, forest fires, and temperature. The analysis of both lung cancer and climate change factor rates proved that there was indeed a relationship between the two of them. In fact, the trend lines for lung cancer and all of the effects and causes that bring and are brought on by climate change have an almost identical trajectory—it's almost as if climate change is the sole and direct cause of lung cancer. In our current day and age with the rise of climate change, the lives of humans and other species are

at stake. Lung cancer, which shows a correlation with climate change, is increasing too. There is a way to prevent lung cancer if we prevent climate change as well in tandem. This research paper will focus on the connection between lung cancer and climate change and will analyze the statistical relationships between the two factors. The expected outcome is that all the factors of climate change show a positive trend with both the incidence and mortality rates of lung cancer.

I investigated some other research papers in Google Scholar and other publication sites regarding the connection between lung cancer and climate change. A limited amount of papers met the criteria of my analysis. There were comprehensive data sets available on national websites, such as the NOAA. I combined these data sets and used them in a machine-learning model to assess the relationship between lung cancer and indicators of climate change and predict future values of lung cancer incidence and death rates.

The rest of the report proceeds as follows. Section 2 of this paper is a literature review and focuses on the findings of other scholars in this field. Section 3 of this paper is Methods and Processes and will highlight the steps used to create the program and get the results. Section 4 of this paper is Results and Analysis, and will go over the results produced by the machine learning algorithm, and will present graphs and visualizations regarding the relationship of the dependent and independent variables. The final section, Section 5, is Limitations and Conclusion, in which we will discuss possible limitations to both my dataset and my model, and will conclude the paper by presenting a big-picture view of these problems in our society.

2. Literature Review

In our paper, we are focusing on the relationship between climate change and lung cancer. By using Google Scholar, I found a myriad of papers that had been written on both climate change and lung cancer independently. However, I struggled to find as many papers that had been written on the relationship between the two subjects as the independent papers themselves. In this section, we will go over the methods and outcomes of all of the different research papers that have been written on these topics, starting with the independent climate change research papers.

One of the first papers which was reviewed which was written on climate change was "Are We Adapting to Climate Change?" by Lea Berrang-Ford, James D. Ford, and Jaclyn Paterson. This paper discussed how climate change is affecting the world, and how information about climate change is much scarcer than it should be. It also talks about how humans and other life are adapting to climate change, and how these adaptations could or could not be successful in the near future.

Another interesting paper on climate change was "Climate Change Mitigation" by Bert Metz. This paper was interesting, as it not only talked about climate change and its changes to society but also how it can be attributed to our

errors in not being able to develop our society in a sustainable and eco-friendly way. This paper put the blame of climate change on society, and explained ways that we can stop climate change by focusing on ourselves and our personal and societal endeavors, rather than trying to change the environment to keep up with our developments.

Aside from looking at independent climate change research papers, many papers written solely on lung cancer were also reviewed. These papers provided me with the necessary biological information needed to understand how lung cancer works and how it changes the human body. One really interesting paper about lung cancer was "One Hundred Years of Lung Cancer" by Stephen G. Spiro and Gerard A. Silvestri. This paper didn't focus extensively on the biological aspect of lung cancer. Rather, it focused on the perception of lung cancer and how its statistics and our attitude toward it have changed over the last century. This paper was really interesting to me as it not only gave me information about lung cancer but also about the medical field and society adapting to it as it changed over time into something more deadly and formidable than it ever was before.

Another insightful paper about lung cancer that I read was "Pathology of Lung Cancer" by EDWARD F. PATZ, JR., M.D., PHILIP C. GOODMAN, M.D., and GEROLD BEPLER, M.D., PH.D. This paper differentiated between the different types of lung cancer and the different causes and effects that they have on the human body. This paper was more biologically oriented and aimed to provide the best explanation for the questions regarding the spread and incidence of lung cancer.

Aside from looking at the papers that highlighted discoveries present in only the respective fields of climate change and lung cancer, it was imperative to examine papers that discussed both of them in relation to one another. Researchers found that lung cancer, which is most directly attributed to climate change, is only about half as deadly as climate change is to the influence of lung cancer.

All in all, the papers that were reviewed provided many insights into climate change, lung cancer, and their relationship. These papers would be instrumental in providing an explanation for the values seen later in the journey and would provide vital context and information on these issues.

3. Methods and Processes

Alongside finding the information, finding a relationship between climate change and lung cancer data was necessary. I used a machine learning algorithm to find a relationship between lung cancer and climate change indicators.

The first step of the project was to build a machine-learning algorithm that could draw relationships between climate change and lung cancer data. In the first few lines of the code, the necessary libraries were imported, such as Numpy, SciKit Learn, MatPlotLib, and Pandas. These would provide various functionalities and tools which would be used in the next sections of the program. In the next lines of code, the data set would be imported. After establishing the inde-

pendent and dependent variables, I would split the data set into the training set and test set. The training set was given to the model, to study and identify a pattern between the independent and dependent variables. After that, the model went through the test set and effectively erased the cancer data from its memory for the test set. It would then apply the patterns it had found in the training set to the test set and would predict the cancer values. After the program calculated the dependent values, it displayed the accuracy score which would show how close the predicted values were to the actual values.

Next, the machine learning method had to be implemented in the program. The first idea that came to mind was a Deep Learning Data set. In Deep Learning, the input variables are fed to the program and are passed through a series of hidden layers, which implement various formulae onto the variables to get the final output variable. However, the data sets used in deep learning models typically have thousands of columns and millions of rows. My final data set only had twenty-six columns and forty rows. As a result, the R^2 score for the deep learning model was −490, which meant that it had an accuracy of −49,000 percent. This was not acceptable, and another method would have to be used instead of the deep learning model. I then used a Multiple Regression Model, which is designed to factor multiple input variables into calculating the final output variable and works best on smaller to medium-sized data sets. This would be a much better option to use than the Deep Learning model, as this is much more designed to be used with smaller datasets that have up to a couple hundred rows and columns, which were present in my dataset. The model was then implemented into the program.

However, the data sets spanned only the years from 1990 to 2019. By applying the previous train/test set split, the program would only predict the cancer values from 2014 to 2019. To predict the future values, I put down empty values for 2020 all the way to 2029 and filled them with temporary values. I wanted to do this because I wanted to predict the future values of climate change and lung cancer. The program wouldn't be enough if it was just reiterating known information—I had to extend this in some manner. Therefore, I predicted the values for the next ten years by setting blank values for them in the table. I then used Simple Linear Regression to draw a line of best fit between my data points and calculate the future values for the independent variables. An image of the data set with the highlighted train and test sets is shown (Table 1).

Table 1. Table of Years with $MMCO_2$. Yellow highlight is predicted values.

Year	CO_2 ($MMCO_2$)
1990	5120.957207
1991	5062.956718
1992	5174.227507
1993	5272.850808

Continued

1994	5364.279285
1995	5425.259696
1996	5612.982752
1997	5688.142511
1998	5733.28055
1999	5803.917834
2000	6010.135928
2001	5907.739935
2002	5946.308145
2003	6010.145463
2004	6112.654584
2005	6132.18327
2006	6052.686215
2007	6130.12276
2008	5915.116465
2009	5480.725731
2010	5679.715249
2011	5546.116067
2012	5344.08598
2013	5480.156537
2014	5679.715249
2015	5376.473125
2016	5252.932175
2017	5212.162345
2018	5377.797353
2019	5262.145074
2020	5344.09
2021	5679.72
2022	5376.47
2023	5364.28
2024	6010.14
2025	6132.18
2026	5377.8
2027	5907.74
2028	5915.12
2029	5262.15

This step was repeated for each one of the climate change indicators. The predicted climate change indicator values were then used to predict the climate change values. The final values were then put into the data set.

The next section will give more insight into the data set, its creation, and its format.

4. Results

Before I created my data set, I had to figure out how to organize them so that they would be easy to understand and analyze and would be easily read by the multiple regression machine learning algorithm. I split my data sets into three categories: the climate change cause data sets, the climate change effect datasets, and the disease datasets. I would get around 5 - 6 datasets for each one of these categories, and then I would group them all up into a large dataset after cleaning them to get the information that I needed. I first set out to find the climate change cause dataset. These would consist of the magnitude of causes of climate change, such as Greenhouse Gas Emissions, Meat Consumption, and Fossil Fuel Usage. In total, I had 13 datasets for the causes of climate change. These datasets were as follows: CO_2 emissions in million metric tons, CH_4 emissions in million metric tons of CO_2 equivalent, N_2O emissions in million metric tons of CO_2 equivalent, Fluorinated Gas Emissions in Million Metric Tons of CO_2 equivalent, Coal Consumption in Million Metric Tons, Oil Consumption in Million Metric Tons, Gas Consumption in Million metric Tons, Beef Production in Million Pounds, Veal Production in Million Pounds, Pork Production in Million Pounds, Lamb and Mutton Production in Million Pounds, Chicken Production in Million Pounds, and Turkey Production in Millions of Pounds. I got all of these datasets ranging from the years of 1990 to 2019. I got the greenhouse gas emission datasets because greenhouse gasses are considered the leading cause of climate change, and when there are more greenhouse gas emissions, the temperature increases which accelerates the process of global warming. I took a variety of greenhouse gasses instead of just one so that the impact of each greenhouse gas could be visualized in comparison with the others. I used the fossil fuel datasets because fossil fuels are the cause of these greenhouse gas emissions. I got the information for the three different types of fossil fuels—coal, oil, and gas, so that I could visualize the impact of each one of them in comparison with each other. I also got the meat production datasets because farm animals, especially cattle, produce methane, which is one of the most prominent greenhouse gasses that leads to climate change. I also got the chicken, goat, pig, and many other animal meat production datasets so that I could, once again, analyze the comparison of the impacts between them. I cleaned them up, put them in individual columns, and put them in my final dataset template. Then, I began gathering the datasets for the climate change effects. These datasets would indicate the magnitude of the climate change effect parameters, such as air pollution and wildfires. In total, I got 8 datasets for the climate change effect parameters. These datasets were as

follows: Temperature Change, O3 Pollutant Median Value in Parts Per Million, O3 Pollutant 10th Percentile Value in Parts Per Million, O3 Pollutant 90th Percentile Value in Parts Per Million, SO_2 Pollutant Median Value in Parts Per Million, SO_2 Pollutant 10th Percentile Value in Parts Per Million, SO_2 Pollutant 90th Percentile Value in Parts Per Million [4] [5]. Number of Forest Fires, and Total Area Burnt in Forest Fires in Acres [6]. I got the temperature change dataset because that is the primary indicator to measure the severity of climate change. All of the greenhouse gasses and fossil fuel consumption lead to increased temperatures, which is why climate change is also called global warming. I got the air pollution datasets because climate change causes air pollution by increasing the concentration of airborne particles, and these airborne particles are the primary cause of lung and bronchus cancer. I also got the forest fire datasets because the increased temperatures cause aridity in forests and increase the likelihood of forest fires. These forest fires release smoke and other air pollutants into the atmosphere and contribute to the incidence rate of lung cancer. The final section of the dataset was the actual lung cancer data. I found 5 datasets for cancer. These datasets consisted of: Lung and Bronchus Cancer Death Rates per 100 k Males, Lung and Bronchus Cancer Death Rates per 100 k Females, Lung and Bronchus Cancer Incidence Rates per 100 k Males, Lung and Bronchus Cancer Incidence Rates per 100 k Females, and Lung and Bronchus Cancer Incidence rates per 100 k of Both Males and Females [6] [7]. I could not find a dataset for the Lung and Bronchus Cancer Death Rates per 100 k of Both Males and Females. Now, I had to organize the dataset so that I could prepare it for my machine-learning model.

The next step was the Data Cleaning Phase. I had all the datasets with me, but I had to shorten them somehow so that it would be usable by the Machine Learning Model. My current datasets were quite cluttered and had a lot of additional unnecessary information which had to be removed as soon as possible. I began to clean up my datasets. Some of my datasets, such as the yearly fossil fuel consumption datasets (Coal Consumption in Million Metric Tons, Oil Consumption in Million Metric Tons, and Gas Consumption in Million metric Tons) and the greenhouse gas datasets (CO_2 emissions in million metric tons, CH_4 emissions in million metric tons of CO_2 equivalent, N_2O emissions in million metric tons of CO_2 equivalent, and Fluorinated Gas Emissions in Million Metric Tons of CO_2 equivalent) were already cleaned for me and were ready to use right out of the gate. I took the year column for these datasets, pasted it into my template, and then took the pollutant datasets, and put that into my template as well. However, some datasets required extensive work to clean, and would take a long time to do so. One of the longest dataset cleaning periods was for the Meat Consumption Datasets [8] (Beef Production in Million Pounds, Veal Production in Million Pounds, Pork Production in Million Pounds, Lamb and Mutton Production in Million Pounds, Chicken Production in Million Pounds, and Turkey Production in Millions of Pounds). This dataset was horribly organized, and I had to go

through a lot of work to make sure that it was in the same format as the rest of the datasets. I put the dataset in Excel, and used Pivot Tables, Sums, and a lot more functions to make sure that the data was easy to read and understand. Once I had got it in the right format, I pasted it into my final template for the data. My final data template contained one column for the year and one column for each of the climate change indicators. There were a total of 20 columns for the climate change parameters. The last 5 columns of my dataset contained the information for lung cancer, which were once again, isolated and placed in their own individual columns.

5. Computational Results

Since the values of the lung cancer data and climate change indicators were only available from 1990 to 2019, there were only 30 training variables. The next ten values (2020 to 2029) were the test variables. The tables below show the predicted values for all of the climate change and lung cancer variables from 2020 to 2029 (Tables 2-6). The r_2 model was used to predict these values, which calculates the absolute squared value of the distance between the predicted and actual values. In this case, my r_2 value was 1, which meant that I had an accuracy of 100 percent, as opposed to the abysmal negative r_2 value I had got in the initial deep learning model.

6. Discussion and Analysis

I expected that all the climate change parameters would be related to the lung cancer values. That is the result that I have achieved. I drew a graph in Excel to visualize the trend and the connection between them, and the trend was clear.

Table 2. Predicted values for $MMCO_2$, CH_4, N_2O, F-Gasses, O3 Median, and O3 10th Percentile.

Year	CO_2 ($MMCO_2$)	CH_4 ($MMCO_2$)	N_2O ($MMCO_2$)	F-Gasses ($MMCO_2$)	O3 Median (ppm)	O3 10th Percentile (ppm)
2020	5344.09	828.34	399.15	162.74	0.08	0.06
2021	5679.72	860.38	415.41	159.03	0.07	0.06
2022	5376.47	838.33	432.65	170.28	0.07	0.06
2023	5364.28	925.04	423.16	90.94	0.08	0.07
2024	6010.14	867.77	419.15	138.33	0.08	0.07
2025	6132.18	852.38	426.9	138.33	0.08	0.07
2026	5377.8	831.39	437.23	172.79	0.07	0.06
2027	5907.74	853.79	421.49	127.87	0.08	0.07
2028	5925.12	869.49	426.62	154.56	0.07	0.07
2029	5262.15	824.66	417.59	177.7	0.07	0.06

Table 3. Predicted values for SO_2 Median, SO_2 10th Percentile, SO_2 90th Percentile, Coal, and Oil.

Year	SO_2 Median (ppb)	SO_2 10th Percentile (ppb)	SO_2 90th Percentile (ppb)	Coal (MM Tons)	Oil (MM Tons)
2020	32.6	8	71.6	922	649
2021	43.04	14.4	100	984	575
2022	23.87	5	59	814	740
2023	109.8	32	172	938	510
2024	83.01	26	163	974	518
2025	78.74	16	158	1026	489
2026	14.56	3.8	17	686	835
2027	87.48	29	203	1023	531
2028	54.83	17	111	1063	546
2029	12.68	3	34	640	920

Table 4. Predicted values for veal, pork, lamb & mutton, chicken, and turkey.

Year	Veal (Million lbs)	Pork (Million lbs)	Lam & Mutton (Million lbs)	Chicken (Million lbs)	Turkey (Million lbs)
2020	118	23,252.5	156.3	37,556	5967.3
2021	134.2	22,436.5	163.6	37,413.9	5644.3
2022	82.5	24,501.3	150.4	40,570.7	5626.6
2023	283	17,658	304	23,846.2	4992.2
2024	215	18,928	230	30,495.2	5402.2
2025	155.8	20,685	187.2	35,881.2	5504.3
2026	75.8	26,314.6	153.3	43,140.1	5878.1
2027	195	19,138	223	31,781.6	5561.7
2028	143.1	23,346.9	173.8	37,465.5	6247.2
2029	74.5	27,637.5	148.5	44,433.6	5817.6

Table 5. Predicted values for cancer death female, cancer deaths male, cancer incidences female, cancer incidences male, and cancer incidences both genders.

Year	Cancer Deaths Female	Cancer Deaths Male	Cancer Incidence Female	Cancer Incidence Male	Cancer Incidence Both Genders
2020	36.5	56.5	46.6	61.1	52.8
2021	38	60.3	47.2	64.1	54.4
2022	33.7	50.1	44.2	56.4	49.5
2023	39.8	86.2	48.2	85.3	63.5

Continued

2024	41.2	76.8	48.8	78.7	61.4
2025	40.8	69.7	51	71.6	59.7
2026	29.4	42.1	42.6	50.7	46
2027	41.1	75.7	48.8	77.1	60.8
2028	39.2	63.9	49	67.4	56.8
2029	28.2	40.3	43.6	49.3	45.9

Table 6. Predicted values for O3 90th percentile, gas, beef, number of fires, and acres burnt.

Year	O3 90th Percentile (ppm)	Gas (MM Tons)	Beef (MM Tons)	Number of Fires	Acres Burnt
2020	0.09	8926	25,912.6	67,774	9,326,238
2021	0.08	7558	26,304.3	71,971	3,422,724
2022	0.07	12,781	23,679.8	68,151	10,125,149
2023	0.1	8389	24,278	79,107	4,073,579
2024	0.1	7733	26,777	92,250	7,393,493
2025	0.09	6901	24,682.6	66,753	8,689,389
2026	0.08	15,360	26,872.4	58,083	8,767,492
2027	0.1	7670	26,107	84,079	3,570,911
2028	0.08	6783	26,561.2	78,979	5,292,468
2029	0.07	17,045	27,154.6	50,477	4,664,364

Especially with the greenhouse gas emissions, air pollution, and fire values, the slope and curve of the climate change were almost identical to the curve of the independent values. Therefore, my predictions for the climate change values relationship with the cancer values were correct.

Currently, a lot of measures are being taken to prevent both climate change and lung cancer. To prevent climate change, programs are being created that spread awareness to the general public to not cut down trees, to use sustainable transport that doesn't pollute the environment, and to consume less meat. Additionally, some corporations are trying to fix the air pollution and greenhouse gas problem by reducing and removing the excess greenhouse gas in the air. Ozone patching is another endeavor that is being carried out, which aims to fix the ozone layer and fill up the patch present above the Antarctic Subcontinent. A lot of efforts are being made to fix lung cancer as well. The search for the cure for cancer is a never-ending search that has been persisting for decades. Chemotherapy, Rehabilitation, and other methods all aim to cure individuals of their cancer and restore some semblance of normalcy back to their lives. If these efforts persist, climate change and lung cancer values will decrease, and the world will

be restored. It is important that these efforts persist and continue, and do not decrease or fatigue. While the world and the people in it focus on preserving the society that we live in, we will surely recover from these problems.

7. Limitations and Conclusion

Some limitations were present in the project which could have hindered progress and would have given unsatisfactory results. One possible limitation could be in my data. My data could have been taken from the wrong source, and could continue misleading and false information which would skew my machine learning algorithm and would give false results. Another possible error could be within my program. I could have used the wrong machine learning method or made an error in my code, which would possibly change the results. I am a high school student who recently learned machine learning, so there could be some fault in experience. However, I think that the results were conclusive enough to give merit to the project, and I am happy with the results and my work on them to improve it as much as possible.

All in all, this project was a huge insight for me into the relationship between climate change and lung cancer. I found out that more than just air pollution, other climate change factors are also linked with increasing rates of lung cancer. It is the duty of all of us to work together and stop the spread of lung cancer and climate change. Only then will we be able to preserve a perfect world for all future generations to come.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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