**COVID-19 and the Weather: A data visualization**

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Capstone Project Proposal

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On January 9th, 2020 the World Health Organization (WHO) announced that a coronavirus related pneumonia had been spreading in Wuhan, China. The US confirmed its first coronavirus case on January 21st, 2020 (American Journal of Managed Care, 2021). By March 11th, 2020 the WHO had declared the COVID-19 pandemic.Since then the US has experienced several waves of increased infection rates that have varied in severity across the country.

There is precedence to think that the COVID-19 virus spreads more easily in certain weather conditions. According to the CDC, COVID-19 can spread from human to human via respiratory droplets in the air. Specifically, the virus is known to spread more easily indoors where there is less air ventilation (CDC, 2020). Dr. Fauci, who serves as the director of the US National Institute of Allergy and Infectious Diseases, spoke about the potential connection between COVID-19 and the weather in April 2020 on ABC’s Good Morning America saying:

There is precedent with other infections like influenza and some of the common more benign coronaviruses that when the weather gets warmer that the virus goes down, that it’s ability to replicate, to spread, it doesn’t like warm, moist weather as much as it likes cold, dry weather. But having said that, one should not assume that we are going to be rescued by a change in the weather. (AP, 2020)

Influenza is another respiratory illness that is spread via respiratory droplets in the air. It is well established that influenza spread is influenced by the weather, which Dr. Fauci alludes to above (Huang et al., 2017; Roussel et al., 2016). Roussel et al. (2016) studied the role of weather on seasonal influenza spread in France. Their study found 2 groups of 3 climatic variables that had a significant impact on seasonal influenza spread at the intra-annual scale. The first group of variables was average temperature, absolute humidity, and daily variation of absolute humidity. The second group of variables was sunshine duration, relative humidity, and daily variation of relative humidity. The impact of these groups of variables on seasonal influenza spread was found to be relatively low, between 3% – 6%. While the coronavirus is certainly not the same thing as the flu it does spread in a very similar manner. This makes the relationship between COVID-19 transmission and the weather worth exploring.

There has been some research published already exploring the relationship between weather and COVID-19. However, results from these studies have been mixed. One literature review published in the International Journal of Environmental Research and Public health analyzed the current available literature on the association between weather and COVID-19 incidence (McClymont & Hu, 2021). This literature review looked for relevant studies on COVID-19 and weather by searching PUBMED, Web of Science and Scopus databases. The 23 articles selected for this review were epidemiological studies that evaluated the relationship between weather variables and COVID-19 transmission up to October 1st, 2020. All 23 articles included temperature in their study. 18 of the 23 studies reported a significant correlation between temperature and COVID-19 incidence. However, of these 18 studies 11 reported a negative correlation while the remaining 7 reported a positive correlation. 16 of the 23 articles included humidity in their assessment. Of these 16, 12 reported significant associations between humidity and COVID-19 incidence. However, of these 12, 4 reported a positive correlation, 6 reported a negative correlation and 2 reported an optimal range of humidity for new cases.

Another study published in the same journal highlighted an issue with the existing research on COVID-19 and weather. Jamshidi et al. (2020) said that existing research on this association only considers weather variables during analysis. In this study instead of just looking at weather variables and their impact on COVID-19 transmission they looked at other important factors such as mobility, homestay, population, and urban density. For their weather variable they used equivalent temperature which is a combination of temperature and humidity. The study evaluated the impact of equivalent temperature on COVID-19 transmission using different scales such as global, regional, US state and US county. At the global scale this study found contradictory patterns between the two. From January to July 2020 the USA, Italy and India showed a positive correlation between the two while China, Brazil and Australia had a negative correlation. At the US county scale equivalent temperature was found to have a contributing factor of <3%. This study recommended using finer scale weather data when incorporating it into a study given how much weather can vary across a country or region. They concluded that weather on its own was a non-influential factor in COVID-19 transmission. Instead, it said that other factors such as urban density and mobility of the population influenced COVID-19 transmission much more than weather.

**New paragraph: here is relationship with all these studies, they are incomplete/windowed** One limitation of both studies is the data that they had to work with. The first research article discussed was received for peer review in November 2020. The second article was received in September 2020. This means that both articles were working with limited COVID-19 data, specifically missing out on spikes that were seen in the United States during the November - January time frame. These articles highlight the fact that there is an ongoing debate right now in the scientific community around weather’s role in the COVID-19 pandmic. ~~These articles highlight the need for continued exploration of the relationship between COVID-19 and the weather.~~

**Creating an env where students can ask questions. ‘We think and we hope these kinds of convos would emerge’**

**‘there is a debate in science right now, who cares about that’, ‘if kids are audience, how do we engage them 🡪 visualization’ Need more rationale for why visualization and simulation stimulate kids thinking. Need to say why visualization is a good tool for this job (citations).** The intended user for my project would be a middle school scientist. I have chosen this population of users for several reasons. The effects of the pandemic have not been limited to any subset of the population. Students across the United States had to abruptly switch to remote learning as the pandemic began. My project aims to allow students to link what they are learning in school to what is happening in the world today. My tool would help facilitate an activity in the classroom, virtual or otherwise, that would allow the students to investigate the hypothesis that weather does, or does not, influence COVID-19 transmission in the United States. According to Nebraska standards for science education, by the 7th grade students should be able to understand evidence for how different factors contribute to the weather and climate. Students should also understand the scientific process for asking questions and carrying out investigations by gathering evidence (<https://cdn.education.ne.gov/wp-content/uploads/2017/10/Nebraska_Science_Standards_Final_10_23.pdf>). My project will help to reinforce these ideas by investigating the question of if weather affects COVID-19 transmission by following the scientific process. Students would be expected to think critically about other factors besides weather that might drive infection rates as well. An activity like this could help drive STEM education by showing students what they are learning in school is related to what is going on in our world today.

Existing research has been aimed at proving or disproving weather's effect on the pandemic. My project aims to allow a user to explore this relationship on their own as opposed to establishing whether one exists or not. My proposed project is a web application that would allow a user to explore the relationship between weather and COVID-19 in different parts of the United States by interacting with a map and several charting widgets that would plot weather and COVID-19 infection data side by side. This will be a map-based web application that allows a user to go to an area of interest in the United States and view COVID-19 data and weather data together for a given date range. A user would be able to view the weather and COVID data using charts that would be linked together. This visualization tool would have several configurable features that a user can set in order to visualize the COVID-19 and weather data, such as: county of interest, date range, lag between weather and COVID-19 data and which weather data points to view alongside the COVID-19 data (temperature, absolute humidity, relative humidity). (**Thinking I should provide a mockup or something of it here?)**

**Describe high level visualation here, in depth during methods.**

**Related Work**

**Why these 3 visualizations? ‘These are not built with any group or learnability purpose other than presenting info, presumably to public’ ‘if our goal is for kids, here are what other things did for kids and this is why I want to build it this way’ ‘the goal is to engage students to critically think about research question, want to equip them with ability to explore on their own so we want a dynamic vis that they can , what they do becomes documented rationale they can present in their conclusion**

In this section I will compare some existing COVID-19 data visualizations to highlight work that is currently out there as well as some gaps in that work. I looked at COVID-19 data visualizations from John Hopkins University of Medicine (John Hopkins, 2021), the COVID Tracking Project at the Atlantic (The COVID Tracking Project, 2021) and the Institute for Health Metrics and Evaluation (IHME) at the University of Washington (Institute for Health Metrics and Evaluation, 2021). I compared the visualizations that these organizations offered along several dimensions. Specifically, I looked at the following: How granular is the COVID-19 data? Which COVID-19 data points are visualized? Does it offer a spatial view? How configurable are the visualizations?

The results of this comparison can be seen in Table 1.

**Table 1**

*Comparison of Existing COVID-19 Data Visualizations*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Organization** | **Granularity of COVID-19 Data** | **COVID-19 Data Points** | **Any Spatial View** | **Configurability of the Visualizations** |
| **John Hopkins** | County, State and Country | Confirmed Cases, Deaths, Tests, Hospital Use | Yes, map of US with counties | Minimal, can toggle the data point plotted |
| **COVID Tracking Project** | State and Country | Confirmed Cases, Deaths, Tests, Hospital Use | Yes, map with hospital use data, a few cartograms | Moderate, can set date range and if data is normalized |
| **IHME** | State and Country | Confirmed Cases, Deaths, Tests, Hospital Use | Yes, most data points can be viewed on a map | Moderate – High, can set date range, if data is normalized and if data should be 7-day rolling averages |

Now I will summarize my findings and discuss how this relates to my visualization. Only one of the organizations, John Hopkins, offered COVID-19 data at the county level in the US. Given that my visualization will show weather and COVID-19 data together, the location granularity of this data becomes more important. Weather in any state can vary greatly across different locations in that state. This is why my visualization will use county level COVID-19 data. All of the organizations offered the same COVID-19 data points in their visualizations (cases, deaths, etc.). For my purposes of allowing a user to compare COVID-19 infection rates to weather patterns I will only be using confirmed COVID-19 case counts.

Since weather and COVID-19 infection rates both have a spatial dimension, a spatial view for my visualization is warranted. This is consistent with the existing visualizations I have looked at, all 3 provided some sort of spatial view for the COVID-19 data. This is why I will be displaying a map to the user that they can interact with in order to view data at their location of interest. These organizations offered a variety of levels of configurability in their visualizations. Given that the purpose of my visualization is to allow a user to explore the data on their own I will offer a high level of configurability in my visualization in order to allow a user to visualize the data in a few different ways.

Existing COVID-19 data visualizations all appear to share two traits that will be different for my visualization. The first is that existing visualizations seem to have the purpose of keeping the general public informed about the pandemic. This makes a lot of sense because keeping the public informed of what is going on helps them make informed decisions in their daily lives. The purpose of my visualization is to allow users, middle school scientists, to explore the relationship between two datasets, weather and COVID-19, and to think critically about this relationship. The second trait that existing visualizations share is that they are only concerned with visualizing COVID-19 data. My project will visualize COVID-19 data alongside weather data.

**Methods**

**Data Sources**

For my COVID-19 data source I will be using one of the datasets generated and maintained by the New York Times hosted on GitHub (The New York Times, 2021). Specifically, I will be using the us-counties.csv dataset. This dataset contains a full history of cumulative COVID-19 cases and deaths by county by day in the US. **Rationalize why this data source.**

For my weather data I will be using an API from Weather Source. Weather Source is a technology company that provides a suite of products that help businesses leverage weather and climate data. On March 16th, 2020 Weather Source opened their API for free to any researchers exploring the relationship between weather and the COVID-19 pandemic. Their Weather History API exposes many different weather data points that can be queried with a date range along with latitude and longitude, or zip code. Data can be returned in an hourly or daily format. For my purposes I will be retrieving average temperature, average relative humidity and average absolute humidity in a daily format.

**7 day rolling average is common to help do X, so I will make this a configurable feature.**

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