A Causal Model of Climate Change Drivers on Public Health
(Technical Paper)

An Analysis of US Climate Change Policy versus the Scientific Consensus
(STS Paper)

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Between 2030 and 2050, it is predicted that climate change effects will cause an increase of 250,000 deaths per year (*Climate Change and Health*, n.d.). Climate change is becoming the largest threat to this and future generations' human health to come. Factors such as rising temperatures, extreme weather conditions, air pollution, rising sea levels, and a decrease in biodiversity are some of the main drivers of climate change, and it is becoming increasingly clear that in order for the human race to survive these uncertain conditions, serious alterations to human behavior need to be made (*The Causes of Climate Change* 2020). Climate change has been strongly associated with many negative public health outcomes, a few of which include infectious diseases, respiratory disease, premature deaths due to extreme weather events, and the deterioration of mental health. Although many correlational studies have linked climate change to negative public health outcomes, few causal studies have been conducted between climate change and the consequential societal disturbance (Zhang et al., 2011). The development of a comprehensive causal model between a climate change driver and a health factor could help further establish the validity of climate change's existence and impact on public health, encourage more climate/health data recording, and set a standardized method for developing climate-health causal links. The technical deliverable will be a causal model between air quality and respiratory mortality, that also incorporates the social vulnerability indices (SVI) generated by the CDC as a means of measuring socioeconomic influence (*CDC's Social Vulnerability Index (SVI)* 2020).

Further analysis of the current lack of behavioral adaptations due to climate change shows a great divide in policymakers' prioritization of the issue. While the science is overwhelmingly synonymous with concluding the risks of climate change, climate change has seemingly consistently been a low priority of the U.S. political agenda. The STS deliverable will include an analysis of the relationship between climate change and U.S. policy, and why legislation is so crucial to making large-scale adaptations. The relationship between climate change and U.S. policy on the issue can be analyzed by looking at previous legislation, case studies, and historical climate assessment reports.

Technical Topic:

Climate change is the largest global health threat of the 21st century. Climate change is defined as the long-term alteration of temperature and typical weather patterns in a given place and includes events such as average increases in the frequency of natural disasters, global temperatures, and exposure to vector-, food-, and water-borne infectious diseases. One of the many contributing factors to climate change is air pollution.

Air pollution causes an estimated 7 million deaths worldwide every year, a statistic that has been on the rise since 2016. From 2030 to 2050, climate change is estimated to cause 250,000 additional deaths due to air pollution, malaria, and heat stress (*Climate Change and Health*, n.d.). When specifically referring to air quality, the annual average levels of fine particulate matter (PM 2.5) declined by 24% between 2009 to 2016, and then experienced a 5% increase between 2016 and 2018 which may be correlated to the rollbacks of the Clean Air Act under the Trump administration (*Harder To Breathe: Air Quality Has Worsened Since 2016*, n.d.). Fine particulate matter (PM) is a term that describes the mixture of solid and liquid particles found in the air, including dirt, soot, air, and PM 2.5 specifically refers to fine inhalable particles with diameter 2.5 micrometers and smaller (US EPA, 2016). Other harmful pollutants contributing to these staggering numbers include NO2, SO2, CO, Ozone, and PM10. Changes in the quality of air, water, and food affect our health through multiple pathways including increases in respiratory and cardiovascular disease, injuries and premature deaths, as well as threats to mental health. Due to the complex processes involved in climate change, the exact extent to which human health outcomes may be influenced by the changing climate remains unclear. In fact, several different interpretations of the severity of climate change exist.

To elucidate the impacts of climate change, a team three biomedical engineering undergraduates, along with an advisor from the MITRE corporation, propose the development of a causal model between climate change drivers and human health outcomes. A primary objective is to identify causal versus correlational links of air pollutants to mortality rates due to respiratory complications in the Virginia, Maryland, and D.C. area over a time span from mid-1999 to mid-2018. The rationale for developing a causal model is that it can help answer questions on what climate variables need to be prioritized without the need for an interventional study that would require randomized controlled trials, which in this case, is increasingly difficult due to the complexity of climate change.

There are three main objectives that will be accomplished in this project. First, the project will aim to collect, process, and integrate historical climate and public health time series data, with a focus on monthly time series data. Mortality rate (due to respiratory disease) time series data will be gathered for the same time period and at equivalent levels (monthly) as the climate time series data in order to compare the two variables. Certain limitations of both climate and health data acquisition for this project exists. One of these boundaries in the scope of data acquisition is the privacy regulations as well as the cost that can be associated with health data (LeSueur, 2019). For example, when attempting to gather hospital admission data, we found that these sources are inaccessible to the public. However, with assistance from MITRE we may still be able to retrieve the data. Another limitation with data acquisition, especially with climate change data, is that there is only daily, frequent data from about the last two decades, and thus a yearly analysis is not sufficient because it will only yield around twenty time points. The time estimate for this data acquisition is completion in the next month to two months. Next, after leveraging information in temporal data, a causal model between a factor of climate change and a public health outcome metric will be developed using computational software such as R and MATLAB. The timeframe for a completion of some causal model, perhaps a simplified version, is in about two months. Third, the model will be validated against data using time-series cross-validation. In cross-validation, certain subsets of the data are used to predict subsequent data and measure the statistical error between the predicted model and the actual data.

This study is novel because although literature has implied correlations between public health outcomes and climate change, the two have not been combined in a causal model thus far. With this project, the increased understanding of climate change will transform how we view the boundaries and determinants of human health. As a long-term goal, this model will help support the prioritization of climate change preventative programs and adaptive resilience plans. Understanding the implications of climate change now will help foster the development of proactive and responsive policies and predictive models to reduce future risks and impacts of climate change.

STS Topic:

The Intergovernmental Panel on Climate Change (IPCC) was assembled by the United Nations more than thirty years ago, in 1988, and yet in those past thirty years a large portion of the world has increased up to one degree Fahrenheit per decade (Lindsey & Dahlman, 2020). This alarming statistic is the result of several contributors' pitfalls and negligence. With regards to addressing climate change dynamics, there are three overarching stakeholders: the scientific community, the general public, and policymakers. Although there is some variability within the scientific community, it will be referred to as one entity. The scientific community will be referenced as unanimous in opinion because an overwhelming majority of climate scientists (97%) believe that climate change is driven by human actions (*Americans views on climate change and climate scientists*, 2019). Although this statistic "has been observed to increase acceptance of climate change," there is still discrepancy within the general public.

Currently, there is a strong divide in the US population with polarized beliefs in regard to the negative health impacts caused by climate change. About half of Americans claim that climate change is due to human activity, and about four in ten expect climate change to harm wildlife, shorelines, and weather plans. As of 2020, the bipartisanship experienced the greatest divide in whether or not climate change should be a top priority, with 85% of Democrats and only 39% of Republicans stating yes, meaning a 46% disparity (*Environmental Protection Rises on the Public's Policy Agenda As Economic Concerns Recede* 2020).

In terms of policy making, there have been several actions by the last presidential administration that have worsened both the divide in beliefs and climate change drivers. This includes the appointment of extremist, right-winged cabinet members, the U.S. withdrawal of the Paris Climate Accords, and the rollbacks of the Clean Water Act, to name a few. However, during the course of this project, a new presidential administration has been established, and thus new policies regarding climate change will be evaluated as they occur.

The STS theory, Actor-Network theory, will be implemented to analyze the different stakeholders' relationships to one another. The actors include the scientific community, the general public, and relevant policy makers within the network of climate change influencers. This theory was developed by Bruno Latour, along with Michel Callon and John Law, and uses the black box metaphor as a way to represent complex categories (L. Catwell et al., 1970). One criticism of this theory is that the importance of particular actors cannot be determined in the absence of "out-of-network" criteria. The implementation of this method requires the author to select which actors are the most relevant, and consequently will always leave out other actors such as nongovernmental organizations and land trusts that might accumulate to change the dynamic of the network entirely. Overall, though, in order to tackle the federal policy of climate change in comparison with climate change data, the ANT suffices.

The research question, thus, is as follows: How is US climate change data by the scientific community translated into public beliefs and policy, and why is it important? This research question is two-fold, and first the validity of climate change will be established, although the consensus within the scientific community is overwhelmingly high. Then, a thorough analysis of policy and policymakers in power will be presented to establish the discrepancies between the two. In order to answer this question, two different research methods will be used. The first is the documentary research method, with a specific focus on historical case studies. Historical cases will be used because they can give insight into companies and events that have shaped public view and policy on climate change. One example that will be analyzed is the ExxonMobil scandal, as this company's actions contribute to the mass confusion of the public regarding climate change (Kennedy & Johnson, 2020). The second research method is policy analysis. The primary analysis focuses on federal policies, but within-state differences in climate change policy will be addressed as well, particularly the policy discrepancies between northern and southern states. For policy analysis, online records of legislation as well as news articles will be used to evaluate policy response (or lack thereof) to climate change. The data will be organized chronologically. The discussion within this paper will a) raise more awareness of this discrepancy and b) have an impact on policymakers and hold them accountable for their actions.

Conclusion:

The final technical deliverable for the proposed Capstone project is a comprehensive causal model between climate change drivers such as particulate matter and public health outcomes such as respiratory disease rates measured through time-series data such as hospital admissions. The STS deliverable is an analysis of the relationship between U.S. policy and climate change data and its importance through the use of historical case studies and policy analysis research methods. These projects both aim to raise awareness of the urgency of drastic climate change behavioral adaptations as well as eventually improve climate change effects and thus public health outcomes.

References

Introduction

Climate change and health. (n.d.). Retrieved October 17, 2020, from https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health

The Causes of Climate Change. (2020, August 18). Retrieved November 02, 2020, from https://climate.nasa.gov/causes/

CDC's Social Vulnerability Index (SVI). (2020, September 15). Retrieved November 02, 2020, from https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

Zhang, D. D., Lee, H. F., Wang, C., Li, B., Pei, Q., Zhang, J., & An, Y. (2011). The causality analysis of climate change and large-scale human crisis. *Proceedings of the National Academy of Sciences*, *108*(42), 17296–17301. https://doi.org/10.1073/pnas.1104268108

Technical Topic

University, C. (n.d.). Harder To Breathe: Air Quality has Worsened Since 2016 - News - Carnegie Mellon University. Retrieved November 02, 2020, from https://www.cmu.edu/news/stories/archives/2019/november/air-quality-worsens.html

Particulate Matter (PM2.5) Trends. (2020, June 08). Retrieved November 02, 2020, from https://www.epa.gov/air-trends/particulate-matter-pm25-trends

LeSueur, D. (2019, January 16). 5 Reasons Healthcare Data Is Unique and Difficult to Measure. Retrieved November 02, 2020, from https://www.healthcatalyst.com/insights/5-reasons-healthcare-data-is-difficult-to-measure

STS Topic

Lindsey, R., & Dahlman, L. (2020, August 14). Climate Change: Global Temperature: NOAA Climate.gov. Retrieved from https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature

Americans' views on climate change and climate scientists. (2019, December 30). Retrieved October 16, 2020, from https://www.pewresearch.org/science/2016/10/04/public-views-on-climate-change-and-climate-scientists/

Environmental Protection Rises on the Public's Policy Agenda As Economic Concerns Recede. (2020, February 13). Retrieved from https://www.pewresearch.org/politics/2020/02/13/as-economic-concerns-recede-environmental-protection-rises-on-the-publics-policy-agenda/

Kennedy, B., & Johnson, C. (2020, August 28). More Americans see climate change as a priority, but Democrats are much more concerned than Republicans. Retrieved November 02, 2020, from https://www.pewresearch.org/fact-tank/2020/02/28/more-americans-see-climate-change-as-a-priority-but-democrats-are-much-more-concerned-than-republicans/

L. Catwell, A., M. Mort, A., P. Singleton, C., DA. Giuse, K., JJ. McGowan, C., Pagliari, C., . . . S. Reeves, M. (1970, January 01). Actor-Network Theory and its role in understanding the implementation of information technology developments in healthcare. Retrieved November 02, 2020, from https://bmcmedinformdecismak.biomedcentral.com/articles/10.1186/1472-6947-10-67