Calculating the effectiveness of restricting people's movement during the pandemic using visual analytics

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Abstract— **We propose a visual data analytics approach to examine how the mobility of people in the U.S. during the COVID-19 pandemic influenced the weekly COVID-19 cases at the county level. We used various visualizations, such as charts and interactive maps, to discover patterns and relationships in the data. Our results indicate that lockdowns helped to reduce the disease transmission, and that their effectiveness depended on their timing and duration. These insights can assist government policy during future pandemics. Our source code is publicly available at `https://github.com/ridhu-uic/FinalProject`.**

I. INTRODUCTION

The COVID-19 pandemic has shown the importance of understanding how human mobility patterns affect the spread of infectious diseases. In this paper, we explore the relationship between mobility and COVID-19 cases in the U.S. during 2019 to 2020, using visual data analytics. We used various visualizations, such as charts and interactive maps, to analyze patterns and relationships in the data.

Our analysis indicates that lockdowns helped to reduce the disease transmission, and that their effectiveness depended on their timing and duration. Our visualizations enabled us to identify hotspots and clusters of COVID-19 cases, as well as mobility patterns that were associated with increased disease transmission.

The insights gained from this analysis can assist government policy during future pandemics, and highlight the importance of data-driven decision-making. The use of visual data analytics proved to be a powerful tool for exploring and communicating insights from complex data sets, and we believe that this approach will continue to be valuable in future research and analysis.

II. RELATED WORKS

Mobility and COVID-19 transmission: Several recent studies have explored the relationship between mobility patterns and COVID-19 transmission. These studies have found that reducing mobility can significantly reduce the effective reproduction number of the disease and that mobility patterns vary by demographic and socioeconomic factors. Additionally, targeted interventions based on mobility data have been suggested as effective strategies for mitigating the spread of the disease.

Social vulnerability and COVID-19 incidence: Other studies have investigated how social vulnerability factors interact with mobility to amplify the disparate impact of COVID-19 incidence across US counties. These studies have shown that higher social vulnerability is associated with higher COVID-19 incidence and that this effect is further amplified by higher mobility. Furthermore, some counties have been identified as particularly vulnerable to outbreaks due to their high mobility and social vulnerability. **Public transportation usage and COVID-19 infection rates:** One study has analyzed the relationship between public transportation usage and COVID-19 infection rates in 13 European cities. The study found a positive correlation between public transportation usage and COVID-19 infection rates, but the correlation varied by city and time period. The study suggests that public transportation usage can be used as a proxy for human mobility and social contact, informing public health policies and interventions. **Urban mobility behavior changes due to COVID-19:** A study has investigated how changes in urban mobility behavior due to the COVID-19 pandemic could have potential long-term effects. The study found a significant decrease in public transportation usage and an increase in walking, cycling, and car usage during the pandemic. Some of these changes are predicted to persist after the pandemic, depending on the perceived safety, convenience, and environmental impact of different modes of transport. **Social distancing as a health behavior:** Another study has explored how social distancing, measured by county-level movement data from smartphones, is related to conventional health behaviors. The study found that counties with higher levels of social distancing tend to have lower levels of unhealthy behaviors and higher levels of healthy behaviors. The study also found that social distancing is influenced by demographic, socioeconomic, and political factors. The study suggests that social distancing can be considered as a health behavior that reflects and affects the overall health status of a population. **Multi-level governance in managing the COVID-19 crisis:** A paper has examined how the COVID-19 pandemic has affected different regions and localities across the world, and how different levels of government have responded to the crisis. The paper identifies some of the main challenges and opportunities for multi-level governance in managing the pandemic, such as coordinating policies and actions, ensuring fiscal sustainability and resilience, and engaging with citizens and stakeholders. The paper also provides some policy recommendations and best practices for enhancing the effectiveness and efficiency of multi-level governance in coping with the pandemic and its aftermath.

The main objective of this work is to examine how people's mobility and COVID-19 cases are related and to provide insights for policy making and intervention design for future pandemics. This work differs from the 6 papers mentioned above by analyzing data over a longer time period

(January 2020 to December 2022) than most of the other papers, which concentrate on shorter or specific time periods. Moreover, other papers were more focused on a small region while we analyzed data from the entire US at both county and state levels.

III. Data Description

The data required for the work was collected from the following sources: US Covid Flows contains the weekly mobility data across the USA county-wise and state-wise. This weekly mobility data across US counties and states were sourced from SafeGraph and prepared by Kang et al., who created a multiscale dynamic human mobility flow dataset in the US during the COVID-19 epidemic and made it publicly available in Scientific Data. The dataset includes the following columns: geoid_o, geoid_d, lng_o, lat_o, lng_d, lat_d, date, visitor_flows, and pop_flows. These columns contain data on the origin and destination geocodes, longitude and latitude coordinates, date, visitor flows, and population flows. To measure the COVID-19 cases at the county and state levels, I used the data from The New York Times, which provides daily updates on the cumulative number of confirmed cases and deaths in the USA. The dataset contains the following columns: date, county, state, fips, cases, and deaths. The population data was gathered from the US Census Bureau.

IV. Research

In this paper, we aim to understand the relationship between people's mobility and COVID-19 cases in the US. We analyze over 50 million data entries from January 2020 to December 2022, covering both county and state levels. We create several maps and plots to visualize the distribution of population, the spread of the virus, and the changes in mobility patterns. We provide insights for policy-making and intervention design for future pandemics. Our work differs from related work by covering a longer time period and a larger geographical scope than most of the other papers, which focus on shorter or specific time periods or smaller regions. We use the following data sources and methods for our analysis:

- County-wise population map: This map shows the population density of each county in the US. We use this map to understand how population distribution affects COVID-19 transmission. We expect areas with higher population density to have higher rates of COVID-19 cases.
- Weekly new COVID-19 cases county-wise maps: These maps show the number of new COVID-19 cases reported in each county for each week. We use these maps to identify new hotspots and trends in the spread of the virus. We track the changes in COVID-19 cases over time and compare them with the population density map.
- Weekly COVID-19 cases county-wise maps: These maps show the total number of COVID-19 cases reported in each county for each week. We use these maps to understand how the virus spread over a longer period of time. We analyze the cumulative impact of COVID-19 on different areas and identify areas that were particularly hard hit by the pandemic.
- Weekly scaled COVID-19 cases map: This map shows the relative number of COVID-19 cases in each county for each week. We use this map to compare the impact of COVID-19 across different counties. We scale the data by population size to account for differences in population density.
- Mobility map-This map shows the changes in mobility patterns for each county for each week. We use this map to understand how mobility affects COVID-19 transmission and how COVID-19 cases affect mobility. We analyze the correlation between mobility and COVID-19 cases for different time periods.
- State Wise plots-These plots show the COVID-19 cases and mobility patterns for each state over time. We use these plots to understand the COVID-19 waves in each state and how they relate to mobility changes. We create three sets of plots: COVID-19 cases from 2020 to 2022, mobility from 2019 to 2021, and a combined plot of COVID-19 cases and mobility for each category.

V. Results

In this section, we present the main findings of our analysis based on the maps and charts we created. We discuss the trends in the spread of COVID-19 cases and the mobility of people over time and across different regions.

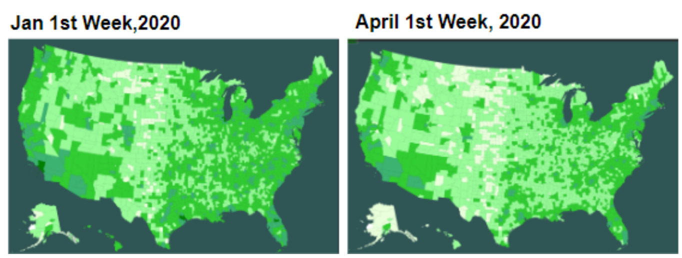

Fig. 1: Mobility map for Jan 2019 and Jan 2020.

The first finding is that the mobility of people increased significantly in January 2020 compared to January 2019. This is likely due to the higher temperature in January 2020 than in January 2019. Figure 1 shows the mobility map for both months, where darker colors indicate higher mobility. We can see that most of the counties had higher mobility in January 2020 than in January 2019. The second finding is that the mobility of people drastically reduced during the third and fourth week of March 2020, when the states introduced lockdowns to contain the spread of the virus. Figure 2 shows the mobility map for March and April 2020, where lighter colors indicate lower mobility. We can see that most of the counties had lower mobility during these weeks than before or after. Moreover, we found that the counties with high mobility during these weeks had the highest cumulative cases after the first wave of COVID-19. The third finding is that after the third peak of COVID-19 cases, which occurred at

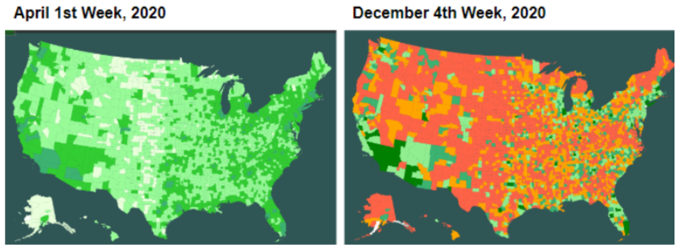

Fig. 2: Mobility map for April 2020 and Distribution of Cummulative Covid Cases across US in Dec 2020.

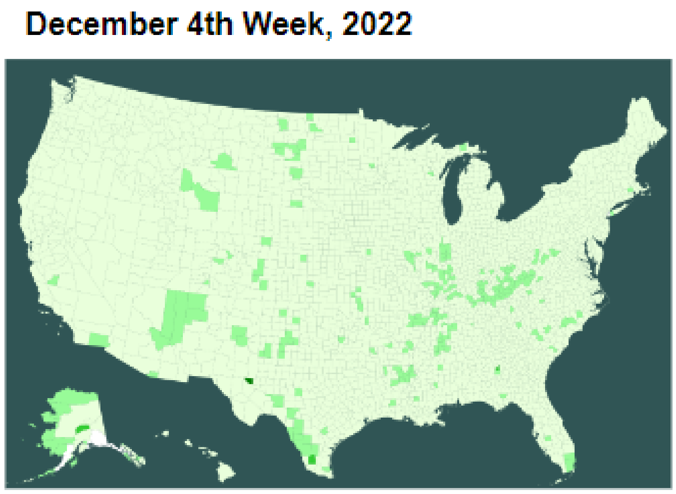

Fig. 3: Distribution of Relative Covid Case Density(no of covid cases/ population) across USA in Dec 2022.

the end of 2021, the density of COVID-19 cases became similar across the country. This suggests that when there are no restrictions in mobility, the number of COVID-19 cases in a region is proportional to the population density in that region. Figure 3 shows the scaled COVID-19 cases map for December 2022, where darker colors indicate higher relative cases. We can see that most of the counties had similar relative cases in this month.

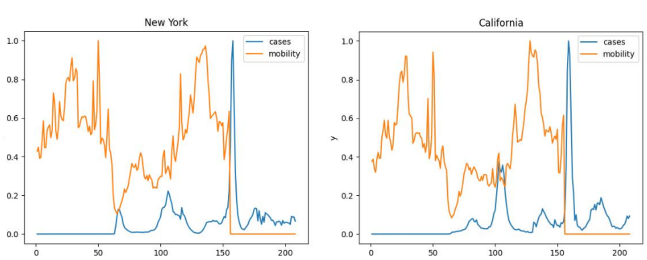

Fig. 4: Plots showing weekly mobility of people from 2019-2021 and new covid cases from 2020-2022.

The fourth finding is that the COVID-19 waves also affect the mobility patterns. Generally, the mobility of people is high before the peak of the wave, as people are less aware or cautious about the virus. As the cases start rising, the mobility of people reduces, either due to voluntary or mandatory measures to reduce transmission. After the peak of the wave, as the cases start decreasing, the mobility of people increases and returns to the previous state after about two to three months.We can see that there is a negative correlation between COVID-19 cases and mobility for most of the states.

VI. Conclusions

The main conclusion of this work is that mobility patterns have a significant impact on the transmission and spread of COVID-19 in the USA. Lockdowns help in slowing down the spread of the disease but do not eliminate it completely. Social distancing and restricting people's movement are effective strategies for controlling the disease. Also, Lockdowns are the best option during the start of the pandemic to study the disease, its effects, and its impact on the society and economy. This work does not consider other factors that may influence mobility and COVID-19 cases, such as social vulnerability, public transportation usage, urban mobility behavior, social distancing as health behavior, and multi-level governance. These factors are explored by some of the other papers.

VII. Source Code

Source code for this project is available at `https://github.com/ridhu-uic/FinalProject`.

VIII. References

1) Association between mobility patterns and COVID-19 transmission in the USA: a mathematical modeling study. The Lancet Infectious Diseases, 2020.
2) Social vulnerability amplifies the disparate impact of mobility on COVID-19 incidence across US counties. Humanities and Social Sciences Communications, 2022.
3) Exploring the relationship between mobility and COVID 19 infection rates using public transportation data. Scientific Reports-2021.
4) Mobility in pandemic times: Exploring changes and long-term effects of COVID-19 on urban mobility behavior. Transportation Research Interdisciplinary Perspectives-2021.
5) Social Distancing as a Health Behavior: County-Level Movement in the United States During the COVID-19 Pandemic Is Associated with Conventional Health Behaviors. Annals of Behavioral Medicine, 2020.
6) The territorial impact of COVID-19: Managing the crisis across levels of government. OECD Policy Responses to Coronavirus (COVID-19), 2020.
7) Kang, Y., Gao, S., Liang, Y. Li, M., Rao, J. and Kruse, J. Multiscale dynamic human mobility flow dataset in the U.S. during the COVID-19 epidemic. Scientific Data 7, 390 (2020). `https://www.nature.com/articles/s41597-020-00734-5`
8) The New York Times. (2021). Coronavirus (Covid-19) Data in the United States. Retrieved from `https://github.com/nytimes/covid-19-data`

9) County Population Totals and Components of Change: 2020-2022 from https://www.census.gov/data/tables/time-series/demo/popest/2020s-counties-total.html

IX. Acknowledgements

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