An Analysis of COVID-19's Unequal Impact on Human Mobility Behaviors

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Introduction

- Each population's mobility behavior has been affected differently by the COVID-19 pandemic for reasons like socioeconomic differences and inability to work from home.
- Common mobility measures are the radius of gyration, k-radius of gyration, unicity, travel diversity, and activity entropy.
- Most studies analyzing the unequal impact of COVID-19 only use these mobility measures to capture the static notions of human behavior rather than the connectivity and spatial structures within mobility networks

Objective

- Analyze the effect of the COVID-19 pandemic on human mobility using various mobility measures
- Capture how change in mobility varies across space

Methods

- Use SafeGraph's daily mobile phone location data in New York and Los Angeles
- Two mobility indicators: Outflow-Weighted Radius of Gyration (OWR_g) and Outflow-Weighted K-Radius of Gyration ($OWKR_g$)
- OWR_g is calculated for each tract pre-pandemic and during the pandemic using the following formula:

$$OWR_g(i) = \sqrt{\frac{\sum_{j=1}^{n}(d_j - d_{wc})^2}{n}}$$

n : the total number of destinations, d_j: the location of destination d_j, d_{wc} : the weighted mean center of all the destinations in the tract

- $OWKR_g$ is calculated for each tract pre-pandemic and during the pandemic using the following formula:

$$OWKR_g(i) = \sqrt{\frac{\sum_{j=1}^{k}(d_j - d_{wc})^2}{k}}$$

k : the number of destinations taken into account, d_{wc} : the weighted mean center of the k destinations in the tract

- Change in mobility is calculated by subtracting the pre-pandemic k-radius of gyration values from the values during the pandemic
- To find the optimal k value, 6 k values (2, 20, 200, 1000, 2000, 3000) were used to calculate change in mobility with $OWKR_g$ and plotted against the change in mobility with OWR_g

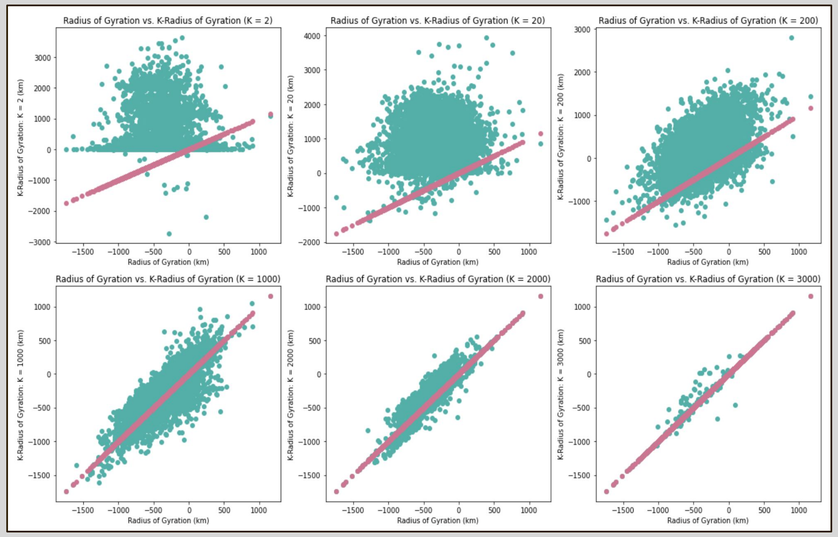

Fig 1. Outflow-Weighted Radius of Gyration vs. Outflow-Weighted K-Radius of Gyration with 6 Different Values of K

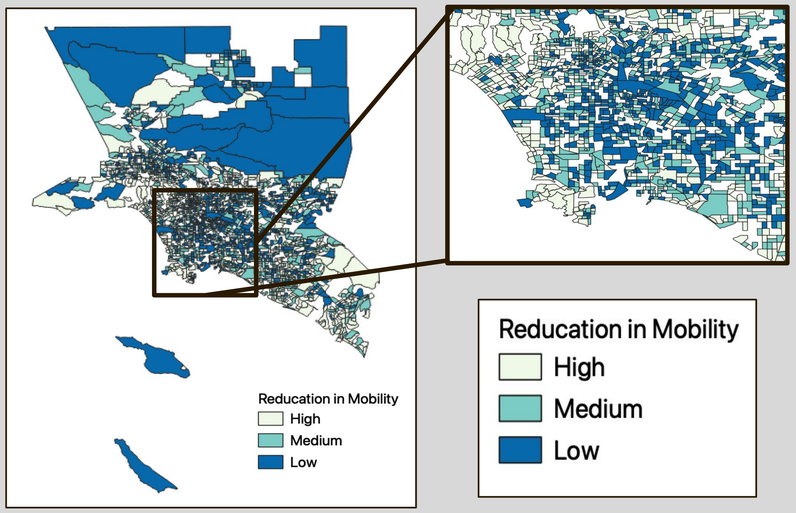

Fig 2. Map of the Reduction in Mobility for Each Tract in Los Angeles

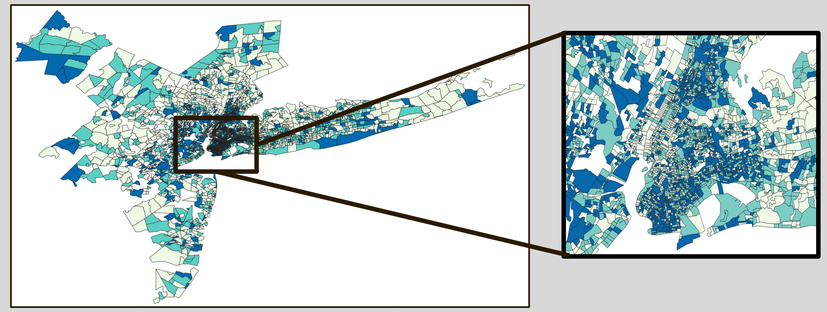

Fig 3. Map of the Reduction in Mobility for Each Tract in New York

Selected References

- Pappalardo, L., Simini, F., Rinzivillo, S., Pedreschi, D., Giannotti, F., & Barabási, A.-L. (2015). Returners and explorers dichotomy in human mobility. Nature Communications, 6(1), 8166. https://doi.org/10.1038/ncomms9166
- Xu, Y., Belyi, A., Bojic, I., & Ratti, C. (2018). Human Mobility and Socioeconomic Status: Analysis of Singapore and Boston. Computers Environment and Urban Systems, 72. https://doi.org/10.1016/j.compenvurbsys.2018.04.001

Results

- After testing the 6 k values, 2000 as the k-value was determined to be the most optimal as it does not overfit to the data, but captures the change in mobility well as shown in the bottom center plot of Fig 1.
- Low reduction of mobility tended to appear in clusters within the center of the major cities, while high reduction of mobility would be at the edges as shown in the zoomed in portions of Fig 2 and Fig 3.

Conclusion and Future Works

- There is a correlation between the location of an individual and the change in mobility
- The distribution of $OWKR_g$ in comparison with the power-law distribution will be plotted,
- Correlations between the spatial variations in mobility change and social vulnerability will be explored