The unequal impact of COVID-19: An analysis of mobility behaviors of socially vulnerable populations

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Geo-Social Lab



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Background

Does COVID-19 affect everyone equally?

• Health inequities in the impact of COVID-19

Can everyone follow social distancing policies and stay at home?

• Importance of understanding human mobility to identify unequal exposure to COVID-19



Image Source: <u>https://www.nytimes.com/2020/04/06/upshot/coronavirus-four-benchmarks-reopening.html</u> (left), <u>https://www.nytimes.com/2020/08/02/nyregion/nyc-subway-coronavirus-safety.html</u> (right)





Disparities in human mobility changes during the pandemic



Rahman, M. M., & Thill, J.C. (2022). Associations between COVID-19 Pandemic, Lockdown Measures and Human Mobility: Longitudinal Evidence from 86 Countries. International Journal of Environmental Research and Public Health, 19(12), Article 12.



Kar, A., Le, H. T. K., & Miller, H. J. (2022). What Is Essential Travel? Socioeconomic Differences in Travel Demand in Columbus, Ohio, during the COVID-19 Lockdown. Annals of the American Association of Geographers, 112(4), 1023–1046.



Research Gap

Can human mobility be a proxy of social vulnerability during the pandemic?

* Social vulnerability: the susceptibility of groups of people to the impact of disasters

- 1. Lack of the measures to capture the **complexity of mobility** (e.g., connectedness between places)
- 2. Lack of understanding of **local associations** between human mobility and social vulnerability



Tate, E., Rahman, M. A., Emrich, C. T., & Sampson, C. C. (2021). Flood exposure and social vulnerability in the United States. *Natural Hazards*, 106(1), 435–457.



Objectives of this study

1. How can we capture the complexity of human mobility?

- Develop network-based mobility measures to capture the connectedness between places
 * This study only includes a new measure of outflow-weighted radius of gyration
- 2. How unequally has COVID-19 affected human mobility?
 - Compute the **changes in mobility behaviors** of each census tract during the pandemic
- 3. How is human mobility associated with social vulnerability during the pandemic? Are there any spatial variations in their association?
 - Identify local associations between mobility changes and social vulnerability

1 Develop a mobility measure and process human mobility data

- Process mobile phone location data provided by SafeGraph
- Develop an 'Outflow-Weighted Radius of Gyration (OWRg)' measure
- Measure OWRg of each tract for the pre-pandemic and lockdown periods

Estimate the changes in human mobility

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Change = OWRg of lockdown period -OWRg of pre-pandemic period



Process social vulnerability data

Social Vulnerability Index Data provided by Centers for Disease Control and Prevention Capture local associations between mobility changes and social vulnerability

Identify spatial variations in their relationship using bivariate LISA

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1. Case study and data

- Study period
 - **Pre-pandemic** period: 01/01/2020 02/29/2020
 - Lockdown period: 04/01/2020 05/31/2020
- Study areas
 - **Tracts** in two most populated metropolitan statistical areas (MSAs) in the U.S.
 - New York-Newark-Jersey City, NY-NJ-PA (NY MSA)
 - Los Angeles-Long Beach-Anaheim, CA (LA MSA)



1. Case study and data

• Data sources

(1) Mobility data: mobile phone location data provided by SafeGraph

• Daily number of visitors between every pair of tracts

	А	В	C
1	origin_census_tract	destination_census_tract	visitors
2	1001020100	36059520401	8
3	1001020100	36059521902	2
4	1001020100	36103122300	1
5	1001020200	36047086000	10
6	1001020400	6037190201	1
7	1001020400	6037190202	5
8	1001020400	6037980028	1
9	1001020500	6037543305	1
10	1001020500	34003029100	3
11	1001030500	24002042202	1 /



1. Case study and data

• Data sources

(2) Social vulnerability data: Social Vulnerability Index (SVI) provided by CDC

• Relative social vulnerability of each tract in the U.S.



Image Source: CDC SVI Documentation 2020 https://www.atsdr.cdc.gov/placeandhealth/svi/documentation/SVI_documentation_2020.html



2. Estimating the changes in human mobility

(1) Measure the spatial range of human mobility from each origin tract

- Develop 'Outflow-Weighted Radius of Gyration (OWRg)'
 - Use outflow-weighted mean center instead of mean center



(2) Estimate the changes in mobility behaviors of each tract

• Subtract OWRg of the pre-pandemic period from OWRg of the lockdown period

3. Identifying local associations between human mobility and social vulnerability

Bivariate local indicators of spatial association (Bivariate LISA)

- Describe the statistical relationship between the value of one variable and the average of surrounding values of another variable
- Capture if the social vulnerability of one tract is surrounded by the high or low level of mobility changes
- Show spatial non-stationarity in the association between mobility change and social vulnerability



Image Source: UCGIS GIS&T Body of Knowledge Document https://gistbok.ucgis.org/bok-topics/local-measures-spatial-association



Results

1. Mobility changes in response to COVID-19 at tract level



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Results

2. Local associations between social vulnerability and mobility changes



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Conclusion

Contribution

- Use of outflow-weighted radius of gyration to estimate the changes in mobility behaviors
- Spatial variations in the association between mobility changes and social vulnerability

What's next?

- Apply and evaluate a series of network-based mobility measures
 - Entropy, clustering coefficient, netflow ratio, etc.
- What makes those variations in their association?
 - Investigate other metropolitan areas with different characteristics
 - Austin-Round Rock-Georgetown, TX Boston-Cambridge-Newton, MA-NH Los Angeles-Long Beach-Anaheim, CA New York-Newark-Jersey City, NY-NJ-PA





Thank you for listening!

Any questions or comments?

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