Investigating Spatial Inequalities in The Disruption of Mobility Networks Before and After the COVID-19 Pandemic Onset

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ABSTRACT:

Disasters such as pandemics, floods, and wildfires significantly alter the connectivity among neighborhoods. Understanding those changes is important because they may have a long-term societal impact on community dynamics, influencing social capital, economic activities, and overall community resilience. During the COVID-19 pandemic when most non-pharmaceutical interventions aimed to restrict mobility behaviors and social interactions, human mobility serves as a key metric for understanding behavioral responses and connectivity changes among neighborhoods due to COVID-19. Previous studies examined human mobility behaviors using measures such as home-dwelling time, traveled distance, and radius of gyration from anonymous mobile phone location data. However, these distance- and time-dependent measures capture static notions of mobility behaviors and often overlook the connectivity and strength of connections among neighborhoods embedded within mobility networks (i.e., mobility network structures). To date, little is known about how COVID-19 has adversely affected mobility network structures and potentially weakened social ties among neighborhoods.

In this study, we investigate the unequal impact of the COVID-19 pandemic on human mobility behaviors by analyzing the relationship between social vulnerability and a diverse set of mobility measures that capture not only distance-, and time-dependent but also topological and structural characteristics of mobility networks. Specifically, we first assess how mobility behaviors are disrupted by comparing mobility behaviors before and after the onset of the COVID-19 pandemic. We then examine local associations between changes in mobility measures and social vulnerability using spatial regression analysis and bivariate local indicators of spatial autocorrelation. Our findings show that places with higher social vulnerability experience shorter home-dwelling times and longer traveling distances than areas with lower social vulnerability. Furthermore, our analysis of structural mobility measures highlights distinct and spatially varying patterns for places with higher social vulnerability: (1) limited and less diverse mobility connections with other neighborhoods, (2) uneven distributions of outgoing and incoming flows, primarily concentrated on a few destinations and origins, and (3) weakened connections with other neighborhoods compared to the pre-pandemic period. These findings indicate that the changes in mobility patterns resulting from NPIs have likely contributed to the decline of social capital, the exacerbation of segregation, and other enduring societal consequences. This study employs the COVID-19 pandemic as a case study but suggests important implications for future pandemics and other disasters, particularly considering the escalating risk of pandemics due to climate change.

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