Optimizing contact tracing policies to intervene in the spread of COVID-19 in San Francisco, CA

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Abstract

COVID-19 success stories from countries using contact tracing as an intervention tool for the pandemic have motivated US counties to pilot opt-in contact tracing applications. Contact tracing involves identifying individuals who came into physical contact with infected individuals. Recent studies show the effectiveness of contact tracing scales with the number of people using the applications. We hypothesize that the effectiveness of contact tracing also depends on the occupation of the user with a large-scale adoption in certain at-risk occupations being particularly valuable for identifying emerging outbreaks. We build on an agent-based epidemiological simulator that resolves spatiotemporal dynamics to model San Francisco, CA, USA. Census, OpenStreetMap, SafeGraph, and Bureau of Labor Statistics data inform the agent dynamics and site characteristics in our simulator. We test different agent occupations that create the contact network, e.g. educators, office workers, restaurant workers, and grocery workers. We use Bayesian Optimization to determine transmission rates in San Francisco, which we validate with transmission rate studies that were recently conducted for COVID-19 in restaurants, homes and grocery stores. Our sensitivity analysis of different sights show that the practices that impact the transmission rate at schools have the greatest impact on the infection rate in San Francisco. The addition of occupation dynamics into our simulator increases the spreading rate of the virus, because each occupation has a different impact on the contact network of a city. We quantify the positive benefits of contact tracing adopted by at-risk occupation workers on the community and distinguish the specific benefits on at-risk occupation workers. We classify to which degree a certain occupation is at risk by quantifying the impact (a) the number of unique contacts and (b) the total number of contacts an individual has for any given work day on the virus spreading rate. We also attempt to constrain if, when, and for how long certain sites should be shut down once exposed to positive cases. Through our research, we are able to identify the occupations, like educators, that are at greatest risk. We use common geophysical data analysis techniques to bring a different set of insights into COVID-19 and policy research.
Our simulator provides a platform to compare our results at the subpopulation scale to real-world data. This allows us to evaluate the effectiveness of different intervention techniques and compare them to observational studies. We find that manual contact tracing (such as through social distancing and word-of-mouth) is more effective than lower compliance rates of automated contact tracing.

### Discussion

#### 1. Subpopulation Results

We observe that education workers are at a higher risk of contracting the virus compared to non-education workers. This is because education workers interact with a large number of people both inside and outside of the workplace, increasing their exposure to the virus.

#### 2. Intervention Techniques

We compare the effectiveness of different intervention techniques, including manual and word-of-mouth contact tracing, to lower compliance rates of automated contact tracing. Our results suggest that manual contact tracing is more effective in reducing the spread of the virus.

#### 3. Comparison to Observational Data

We compare our simulation results to observational data from different regions. Our simulations predict that manual contact tracing is significantly better than automated contact tracing, particularly in areas where the virus spreads most away from home, such as classrooms and offices.

#### 4. Future Work

Our future work includes incorporating more detailed data and refining our models to better reflect real-world conditions. We also plan to conduct additional simulations to evaluate the effectiveness of different intervention strategies in different scenarios.