Delineo: Data-Driven Simulation of COVID-19 Spread for Community-Level Decision and Resilience

Innovations in data precision and modeling have enabled safer and more effective strategies to be implemented. The Delineo model is a user-centered, public health-oriented simulation that promotes equity, engagement, and informed decision-making through a shared understanding of COVID-19 and future transmissible diseases. This model is designed to drive policy and action, supporting public health experts, policymakers, researchers, teachers, and students. It provides a framework for understanding the spread of COVID-19 and future transmissible diseases, allowing for more tailored strategies to mitigate the spread in specific communities.

Since the first emergence of SARS-CoV-2 in December 2019, COVID-19 has become a public health crisis and challenge all over the world. However, questions remain on its modes of transmission, treatments, and vaccines even after a year of the initial outbreak. Although many projection models have been launched to estimate the number of cases and deaths, these models failed to account for different types of communities and environments people live in. In that, significant insights into the mechanisms for disease spread at the community level is necessary and significant, especially across an extremely diverse array of communities, each with its own structure and idiosyncrasies.

Therefore, to address this issue, the Delineo proposes a combination of agent-based and compartment models that brings variability and adaptability to each community, and connects bullying by utilizing geolocation and demographic data to simulate interactions, Delineo predicts the spread of the virus in an individualized, complex setting and under targeted environments. Our goal is for Delineo to fill this critical gap by providing a community-level simulator to public health experts and decision-makers so that they have the tools they need to navigate the maze of uncertainty created by these invisible threats.

Objectives

1. **Simulation Model & Synthesis**
   - There are two phases built into our simulation. The pre-iteration phase involves the creation of a synthetic population using an open-source project called SynthPop, a reimplemention of PopSim using the modern scientific Python stack. After incorporating additional demographic information as gender, age, race, and socioeconomic status into the synthetic population through existing census data, the underlying medical conditions, and exposure information, the synthetic population are then assigned to each geographic location. Additionally, our team sources and applies various datasets that informed our synthetic population. We consult experts in the field to determine the best methods in addition to leveraging our own synthetic population.

2. **Agent Mobility Patterns**
   - Iterative Proportional Fitting Procedure (IPFP), a classical algorithm in computer science that assembles data scaling based on current datasets, to create a mobility network containing information about the number of individuals (agents) traveling from each Census Block Group (CBG) to Point of Interest (POI). A Census Block Group is the smallest geographical unit for which the Census Bureau publishes sample data and has a population of around 600 to 3000 people. We define a POI as any location (facility) that an agent can visit such as a coffee shop, school, workplace, etc.

3. **Severity-Based Disease Model**
   - The Delineo community-level COVID-19 simulator has the goal of piercing the veil of pandemic spread by providing:
     - **1)** insights into how COVID-19 and future transmissible diseases spread at the local level for specific communities, and
     - **2)** an environment for users to explore which interventions tailored to the local level are the most effective at containing the disease, leading to the novel concept of precision public health.

4. **Materials and Methods**
   - We consulted experts in the field to determine the best methods in creating our novel disease model. Their mentorship led us to the utilization of the Iterative Proportional Fitting Procedure (IPFP) and the Wells-Riley equation as described in the following sections. Additionally, research was done to generate informed conclusions about the general disease characteristics of COVID-19 as well as trends in contagiousness, transmissibility, and disease trajectory.

5. **Results**
   - The Delineo community-level COVID-19 simulator offers a tool for public health experts, policymakers, researchers, and teachers to simulate the spread in a real-world setting and for additional information.

6. **Conclusion**
   - Community-based simulation is a critical component for understanding the mechanisms underlying the spread of disease. Delineo, and its simplified version Anytown USA, provides a tool for public health experts, policymakers, researchers, and teachers to simulate the spread of COVID-19 to design safe and effective preventative measures and intervention strategies. Please visit [www.covidweb.jhu.edu](http://www.covidweb.jhu.edu) to use Anytown USA and for additional information.