Delineo Disease Modeling: Community-level Disease Simulation

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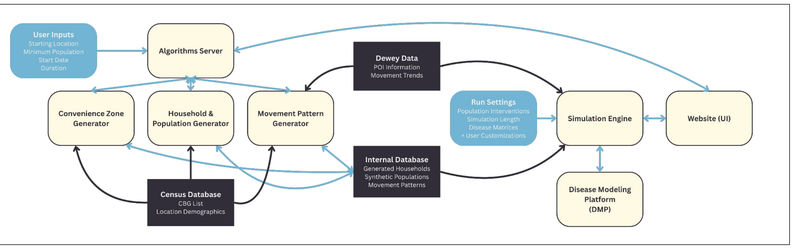
Overview

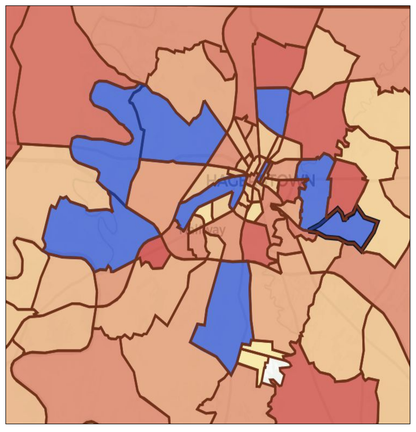
Delineo is a community-level web-based disease simulator for modeling how respiratory diseases spread within specific communities. By simulating localized zones with limited mobility, it represents settings such as restaurants, offices, gyms, schools, and households where transmission occurs. Users can customize disease and population parameters, interventions, layouts, demographics, movement patterns, and infectivity levels. This enables repeatable simulations tailored to local conditions and provides insight into precision interventions that may outperform broad population-wide measures.

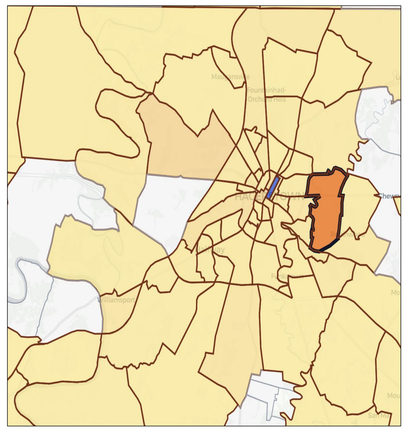


Our workflow is integrated through a centralized Data Library, where generated data is uploaded and retrieved to ensure efficient, secure data access across teams and enhance user interactions.

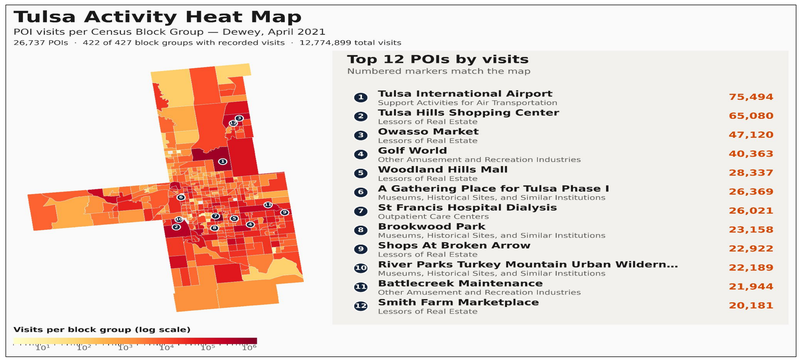
Convenience Zone Generation

A convenience zone is a constructed geographic region that aims to minimize the number of people entering or leaving to allow for simulation of zones independently. Using U.S. Census data and Dewey movement patterns, our convenience zone generation algorithm analyzes how individuals travel between census block groups (CBGs). It generates a dynamic visualization that reveals population connectivity between different CBGs over time for any selected city and population, as shown below for Hagerstown, MD.





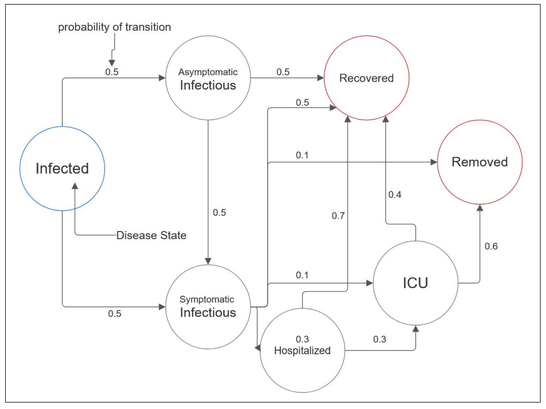
Modeling Real-World Movement



Population movement trends come from the Dewey dataset built off of geolocated phone pings. Census demographic data is used to generate synthetic populations whose movement is modeled after the supplied Dewey data, assigning people to roles (e.g. jobs/schools). In future work, agent movement will be driven by a three-pass system: hard-scheduled anchors (work/school/routines) first, followed by need-based assignment that fills POIs to Dewey capacity targets using a constraint satisfaction approach. Agents accumulate location preferences over time through repeated free choices–an ant colony-inspired mechanism where visiting a place by choice, rather than necessity, gradually increases the probability of returning. Mobility is stratified by agent type and age, with user tunable dials controlling the proportion of local, mid-distance, and long-distance movers as well as discounts for children and older adults, allowing researchers to study how population mobility patterns influence disease spread across different communities.

Disease Model Platform (DMP)

The DMP determines an individual's disease "timeline" as they progress through disease states from the moment of infection. The DMP transitions infected people between states based on user-provided, demographic-specific state machines defining how different groups of individuals live through disease over time.



Simulator & Website

By utilizing precomputed algorithms for clustering, population data, households, and movement patterns, our simulator models disease spread within a pre-generated geographic cluster. Each component is modular, allowing advanced users to easily swap them out. The Delineo disease simulator website combines these precomputed steps with the simulator into an intuitive UI.

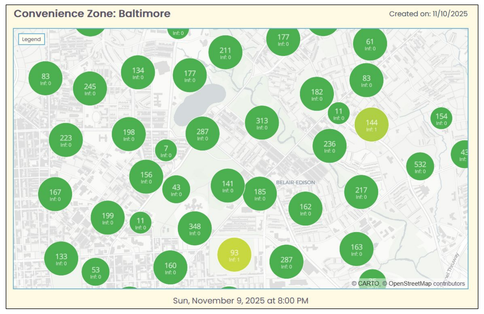
Identifying Hotspots

Delineo builds an event-based contact graph modeling how individuals interact over time and how infections spread through those interactions. At every timestep, interactions are tracked with time, location, infectiousness metadata (e.g. masking) or environmental context.

We can approximate the minimum vertex cover of the contact graph, finding individuals whose behavior affects the entire network, allowing us to test outcomes with vaccination or other infectiousness variables. With this graph, we can also identify hotspots by finding locations with high density which can inform future interventions for transmission. By analyzing node importance through degree centrality, edge weights, and temporal clustering, we can also find individuals that act as superspreaders disproportionately affecting outbreak dynamics. With this contact-based graph structure, we can move from simulating disease spread to understanding the structure of transmission.

Ripple Effect Modeling of Firm-Level Shutdowns

This tool estimates the regional economic impact of firm shutdowns by combining firm-level data (revenue, payroll, employment) with BEA RIMS II multipliers to quantify direct, indirect, and induced losses. Users define a firm, industry (NAICS), and shutdown intensity; the model applies Type I/II multipliers to propagate losses through the local supply chain and household spending channels. Outputs will include scenario-based revenue and employment loss estimates decomposed into direct, indirect, and induced components with best/worst-case prediction intervals.



The simulator model map visualization from the website, where users can edit population-wide interventions and scrub through the timeline to see how disease transmission changes over time. Users can follow specific people as they move throughout the simulation, or specific facilities/households of interest.

External Collaborations

World Health Organization (WHO) & Ruvos

The Delineo team has partnered with Ruvos, a public-health software and information company, and NTT Data, to land a major contract to build a Decision-Support Pandemic Simulator (DSPS) to be used by WHO and partners around the world.

University of Tsukuba

The Delineo team also keeps close contact with several students and faculty at the University of Tsukuba in Japan. Our focus on collaboration on simulator aspects such as realism and generalizability.