THE LINK BETWEEN PUBLIC HEALTH AND PUBLIC TRANSPORTATION: AN AGENT-BASED MODEL(ABM) ANALYSIS

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PROJECT INTRODUCTION

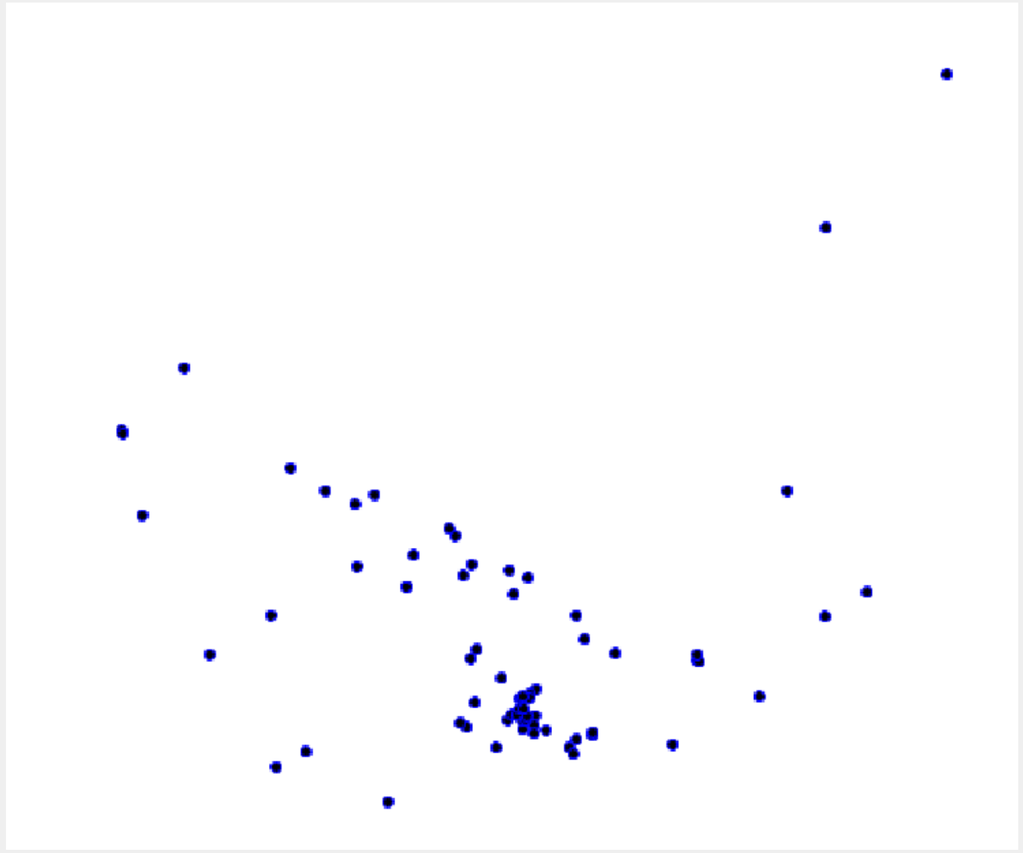
In modern cities, public health and transportation are closely intertwined. Urban populations heavily depend on public transit for daily activities, including healthcare access. However, dense urban environments also accelerate disease transmission. An advanced Agent-Based Model (ABM) simulates these dynamics to provide insights into disease spread and intervention effectiveness in urban settings.

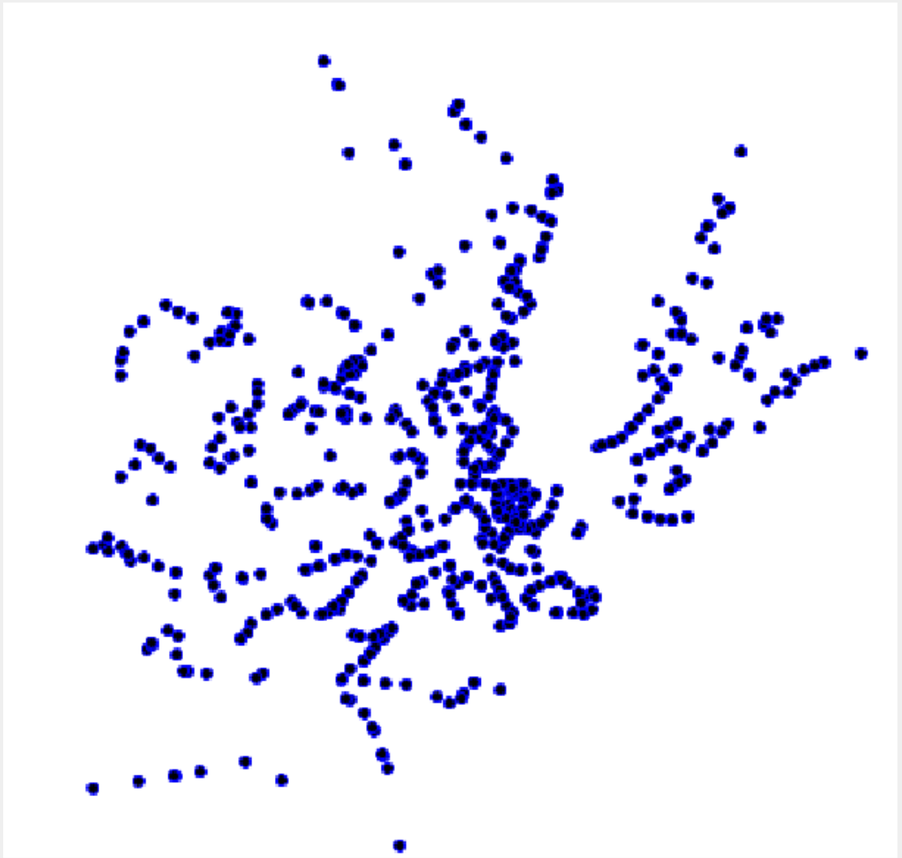
USER CASE

The model replicates the setting of Geneva Canton, focusing on a population comprising both infected and healthy individuals. These individuals navigate between their residences, hospitals, and social gatherings using walking or public transportation options. Hospitals offer healthcare services, while TPG stops serve as hubs for accessing transportation services.

Information associated with healthcare centers and the TPG stops across the canton were incorporated.

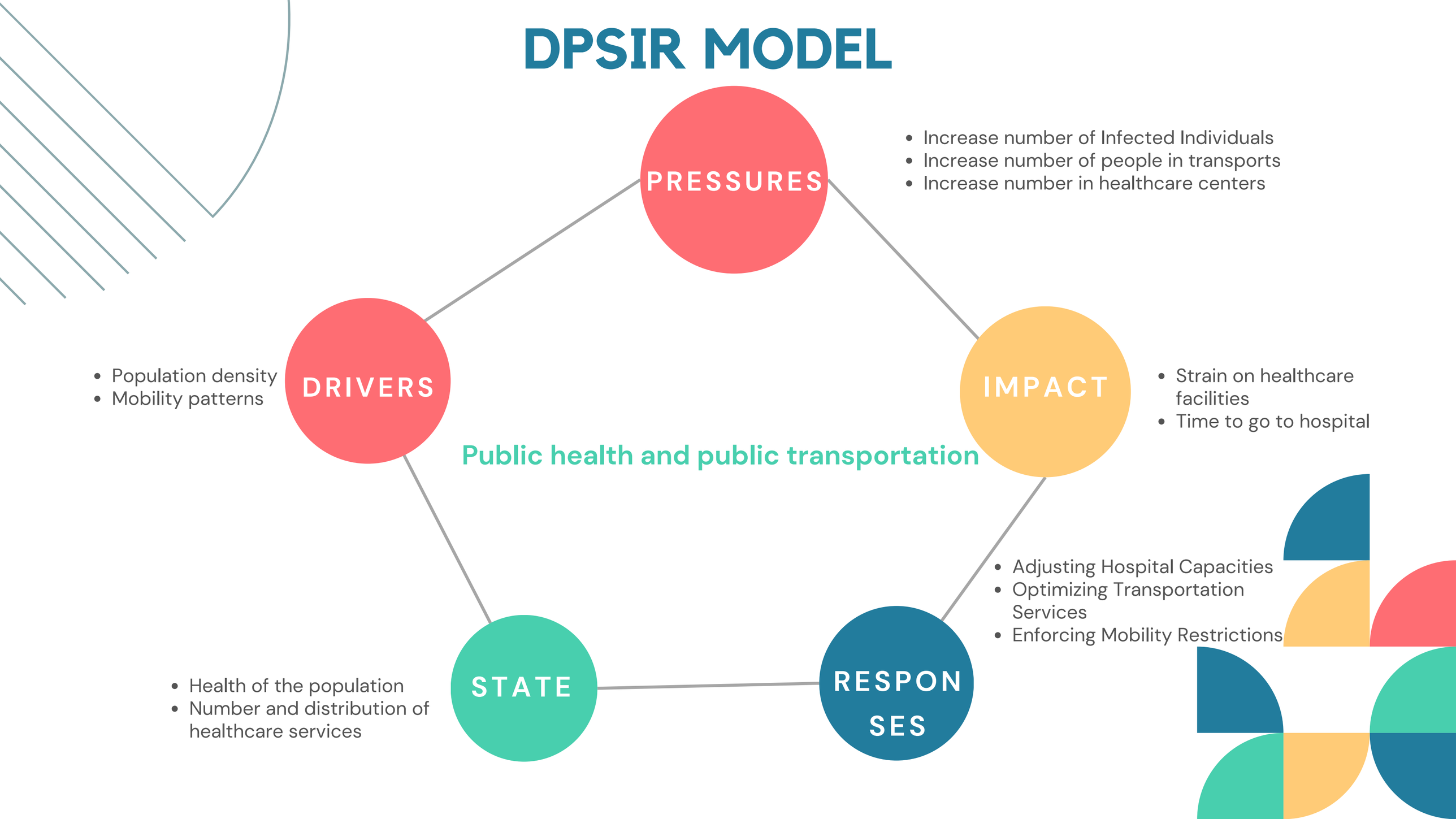
data from : https:\\ge.ch\sitg\





Distribution of healthcare centers(left) and TPG stops (right) within the canton of Geneva

DPSIR MODEL



- Increase number of Infected Individuals
- Increase number of people in transports
- Increase number in healthcare centers

- Population density
- Mobility patterns

- Strain on healthcare facilities
- Time to go to hospital

- Adjusting Hospital Capacities
- Optimizing Transportation Services
- Enforcing Mobility Restrictions

- Health of the population
- Number and distribution of healthcare services

AGENT-BASED MODEL

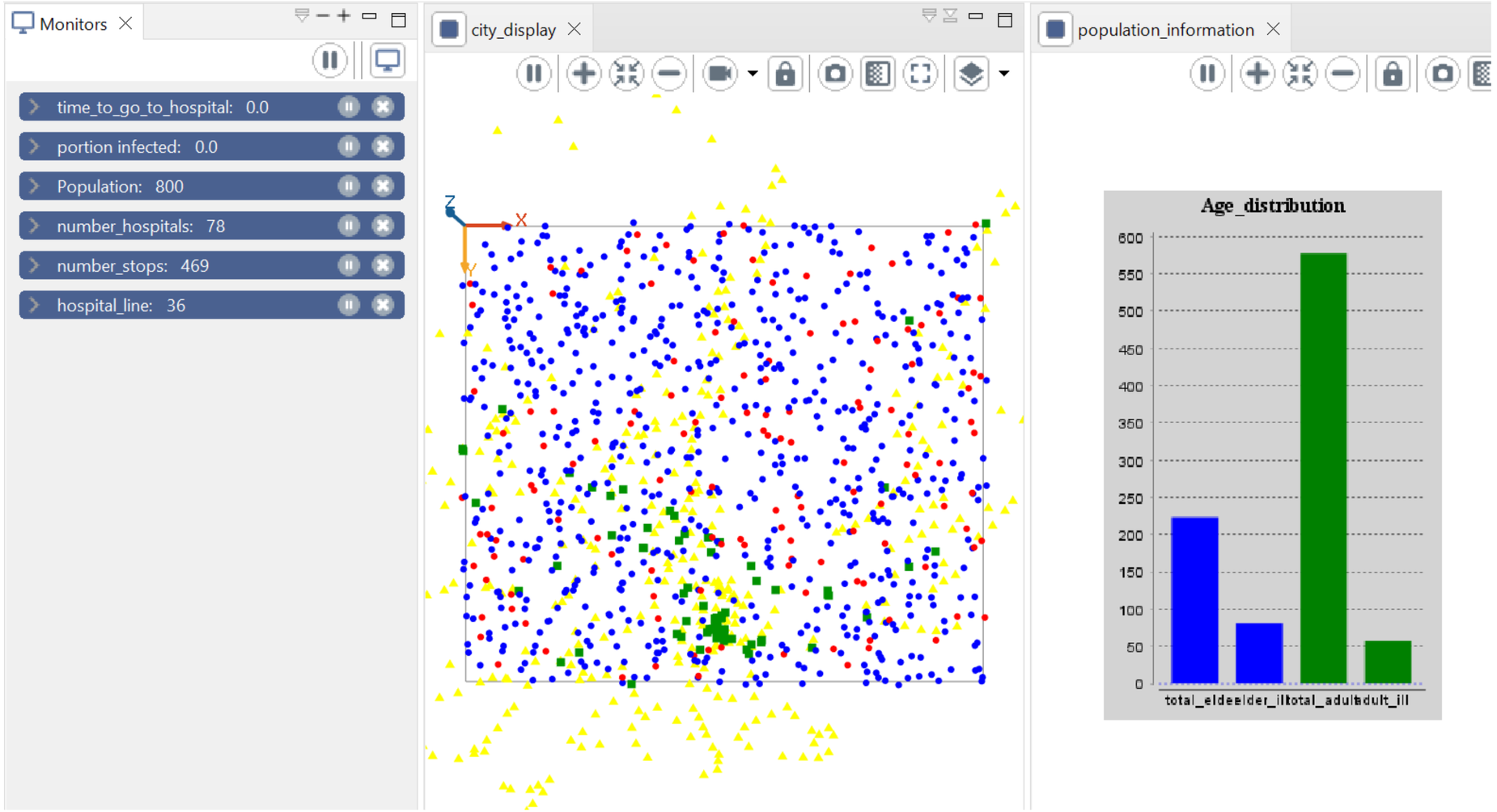
TPG STOPS

TPG stop agents represent public transport stops

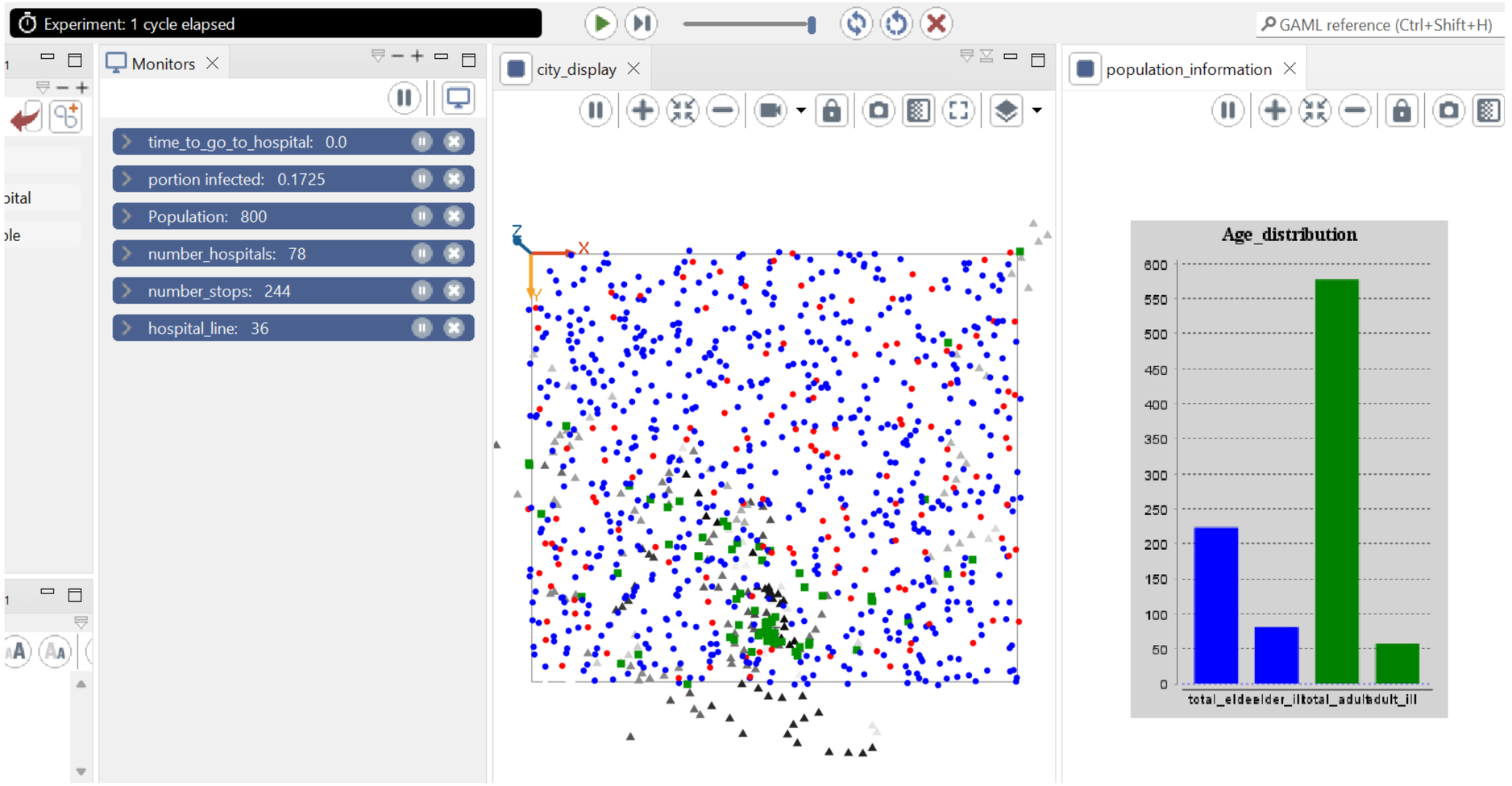
```
species tpg_stop{
    rgb color;
    string line;
    list<hospital> hospital_near;
```

TPG stops are initialized based on geographic data and detect their proximity to hospitals

INITIALISATION



CYCLE 1


Experiment: 1 cycle elapsed
GAML reference (Ctrl+Shift+H)
Monitors
time_to_go_to_hospital: 0.0
portion infected: 0.1725
Population: 800
number_hospitals: 78
number_stops: 244
hospital_line: 36
city_display
population_information
Z
X
Y
Age_distribution
600
550
500
450
400
350
300
250
200
150
100
50
0
total_eldeelder_illtotal_adultadult_ill

HOSPITALS

Hospital agents represent healthcare centers dedicated to treating infected patients

```
species hospital {
    rgb color <- #green;
    point address;
    int capacity;
    list<people> patients <- nil;
    int number_people <- 0 update: length(patients);
```

PEOPLE

Each person is represented by the ‘people’ species

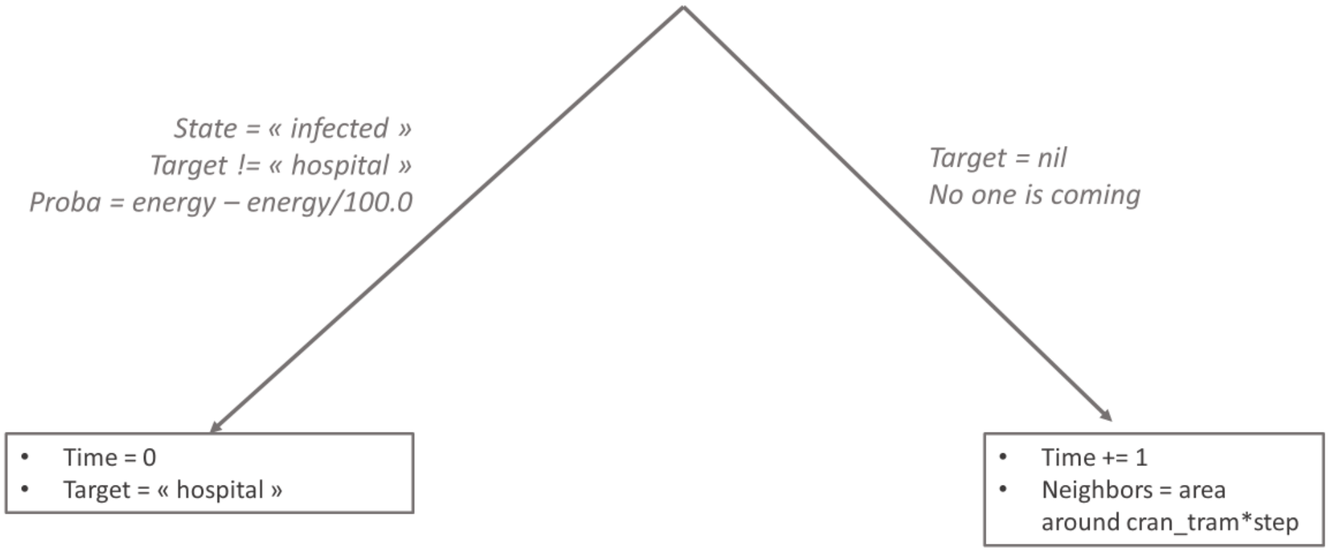
```
species people {
    point home;
    string category;
    string state;
    string target <- nil;
    people friend <- nil;
    int time_with_friend <- 3;
    float energy <- 100.0;
    float step;
    int time <- 0;
    string way <- "walk";
    float get_contaminate;
    float go_see_friend;
    float choose_tram;
    float tram_transport <-10.0;
    list<hospital> hopitaux_proches <- nil;
    list<point> add_hopitaux <- nil;
    list<tpg_stop> stop_near <- nil;
    list<tpg_stop> pathway<- nil;
```

```
if flip(0.73) {category <- "adult";
               get_contaminate <- 0.0013;
               go_see_friend <- 0.5;
               choose_tram <- 0.3;
               step <- 100.0;
               state <- "healthy";
               if flip(0.05){state <- "infected";} }
 else {category <- "elder";
               get_contaminate <- 0.016;
               go_see_friend <- 0.1;
               choose_tram <- 0.8;
               step <- 50.0;
               state <- "healthy";
               if flip(0.2){state <- "infected";}}
```

People have reflexes to handle infection, change targets (e.g., hospital or friend's house), navigate to hospitals or friends' homes, and manage interactions with the environment.

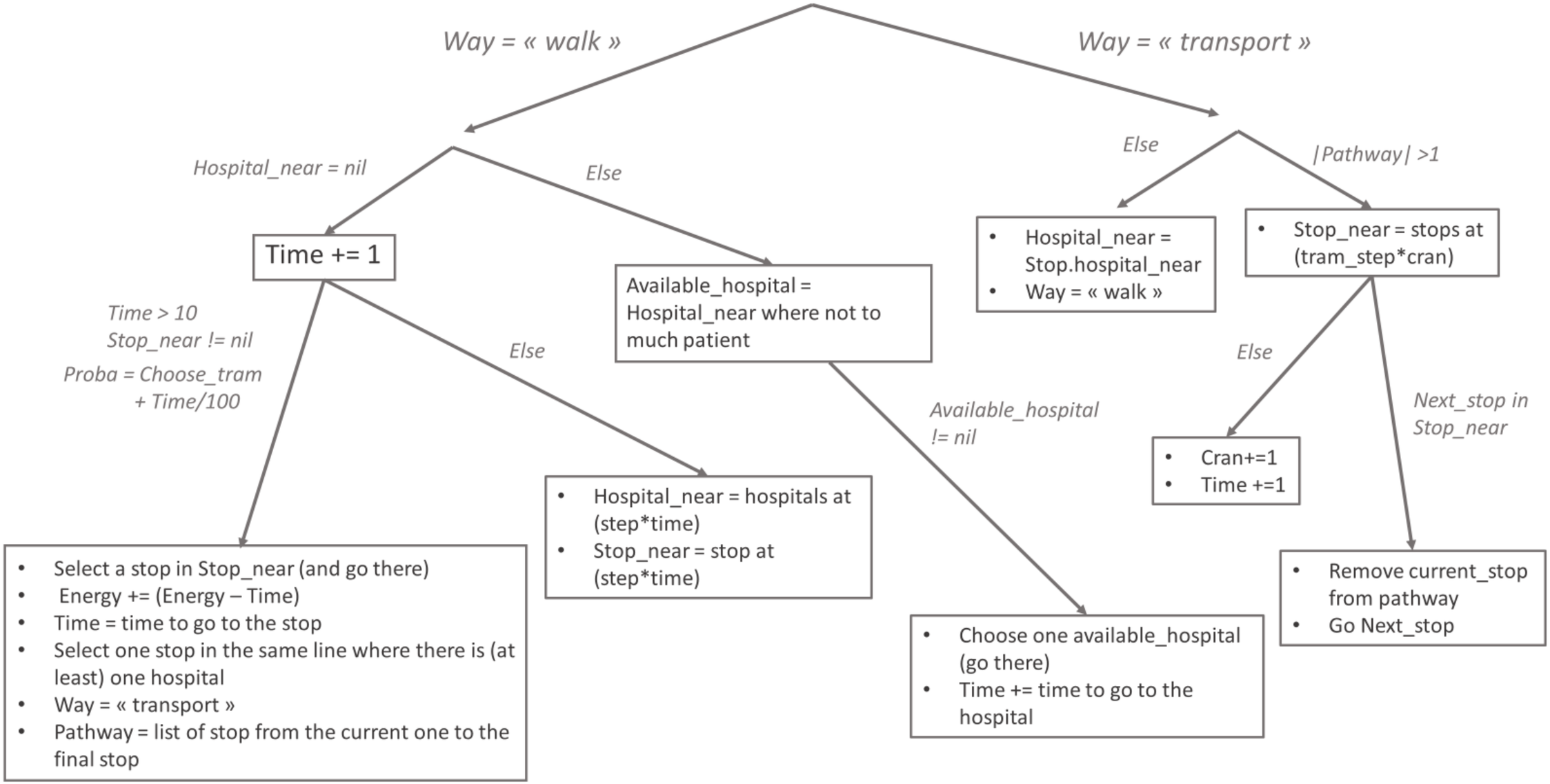
PEOPLE

Change_target :



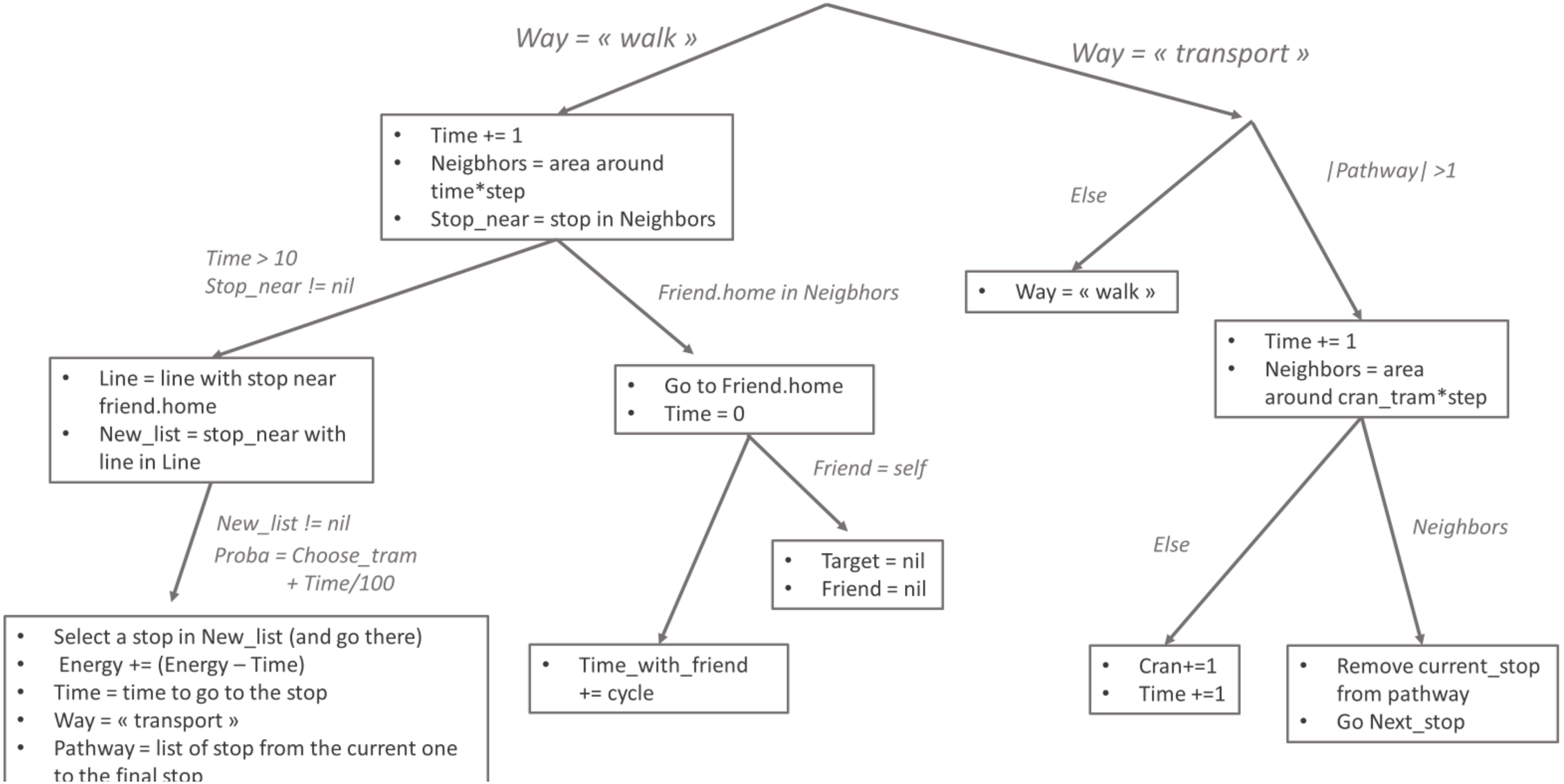
PEOPLE

Go_hospital : Target = « hospital », state = « infected », location not in any hospital



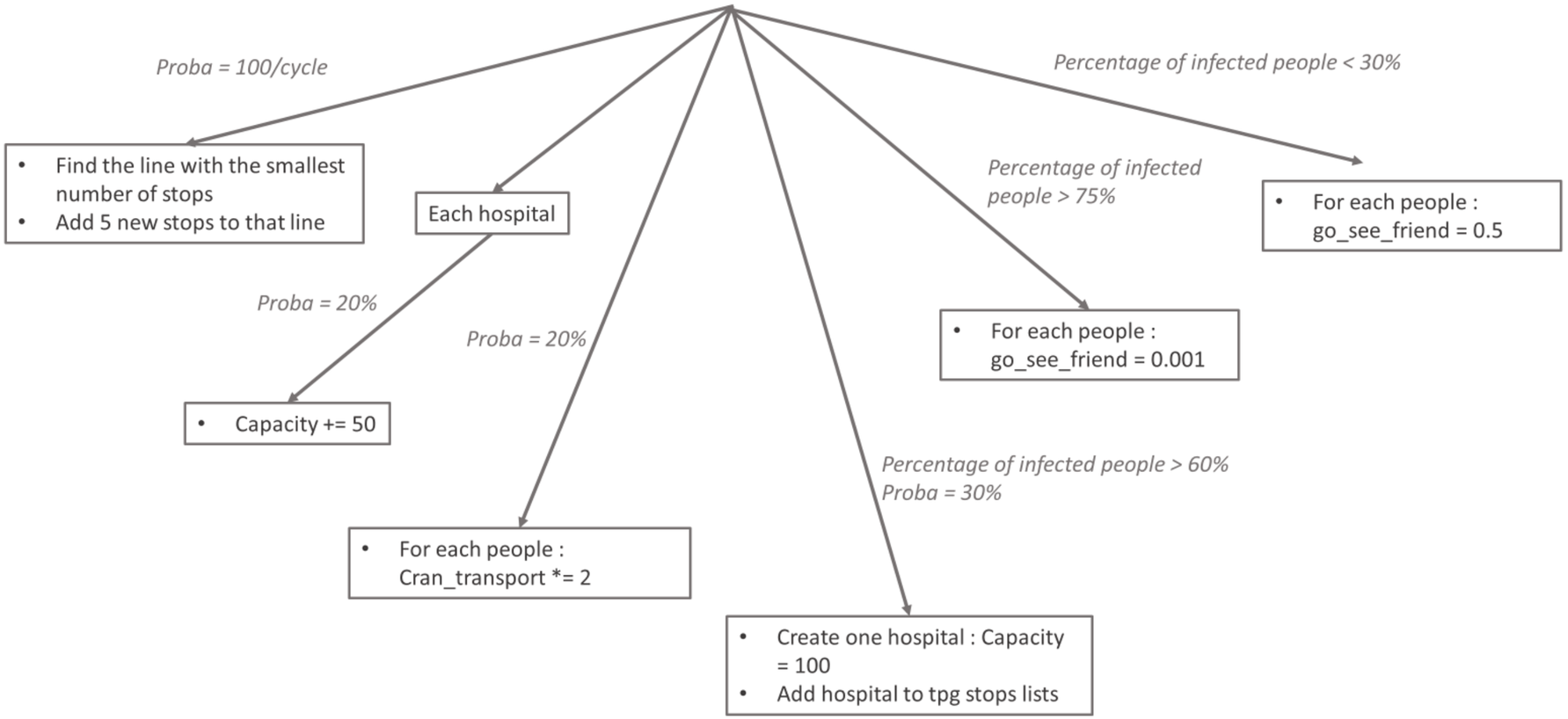
PEOPLE

Go_meet_friend : Friend != nil, agent not in friend.home



REACTION OF ENVIRONMENT

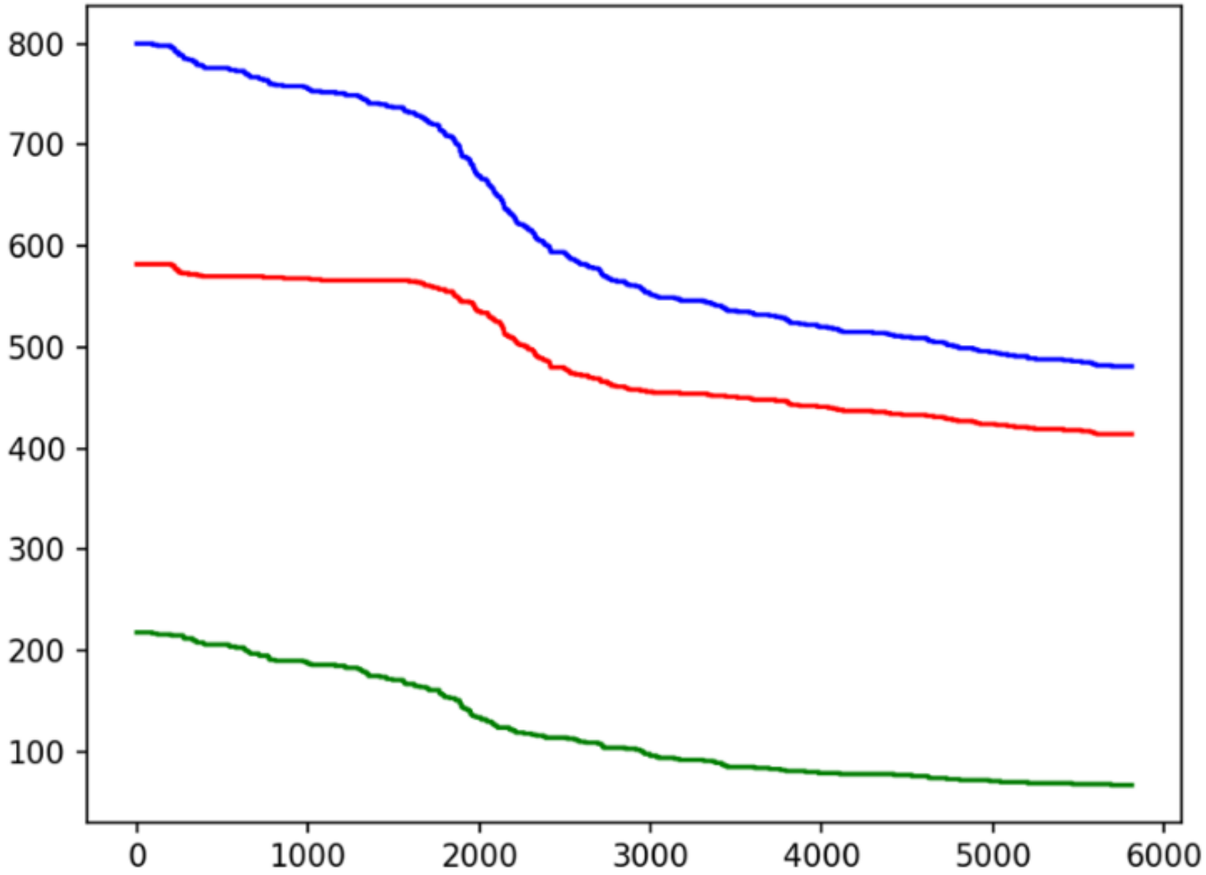
Environment_reaction : percentage of people infected >= 20%



EXPECTED RESULTS

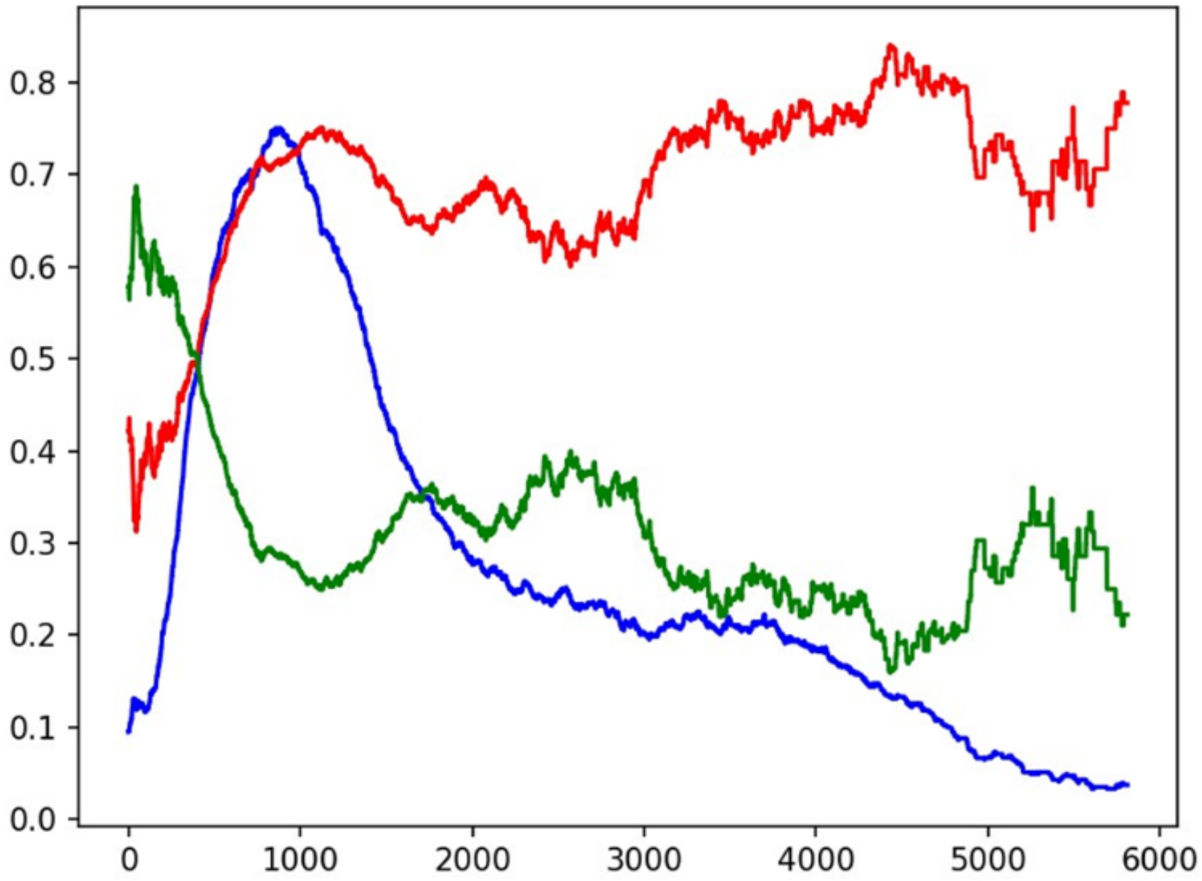
If the model performs as anticipated, more transport stops near hospitals as well as more healthcare centers should correlate with a lower rate of infection in the population and less time to go to hospital.

RESULTS



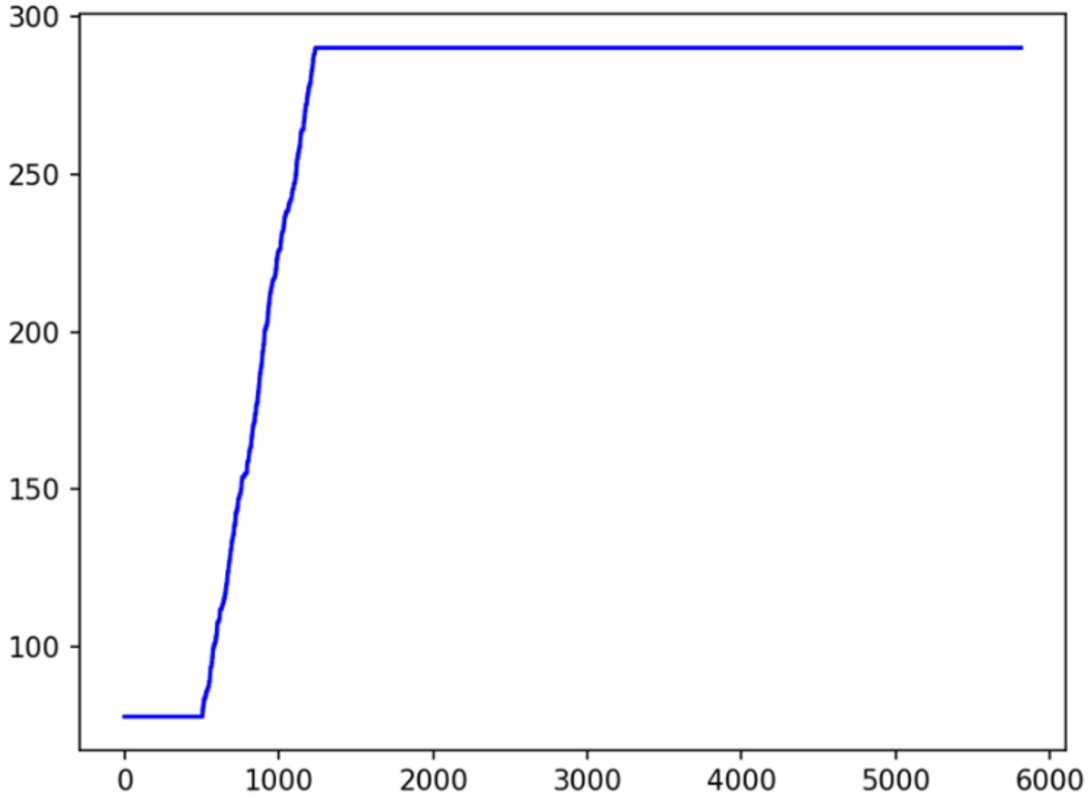
Evolution of the population (blue), the number of elders (green) and the number of adults (red)

RESULTS

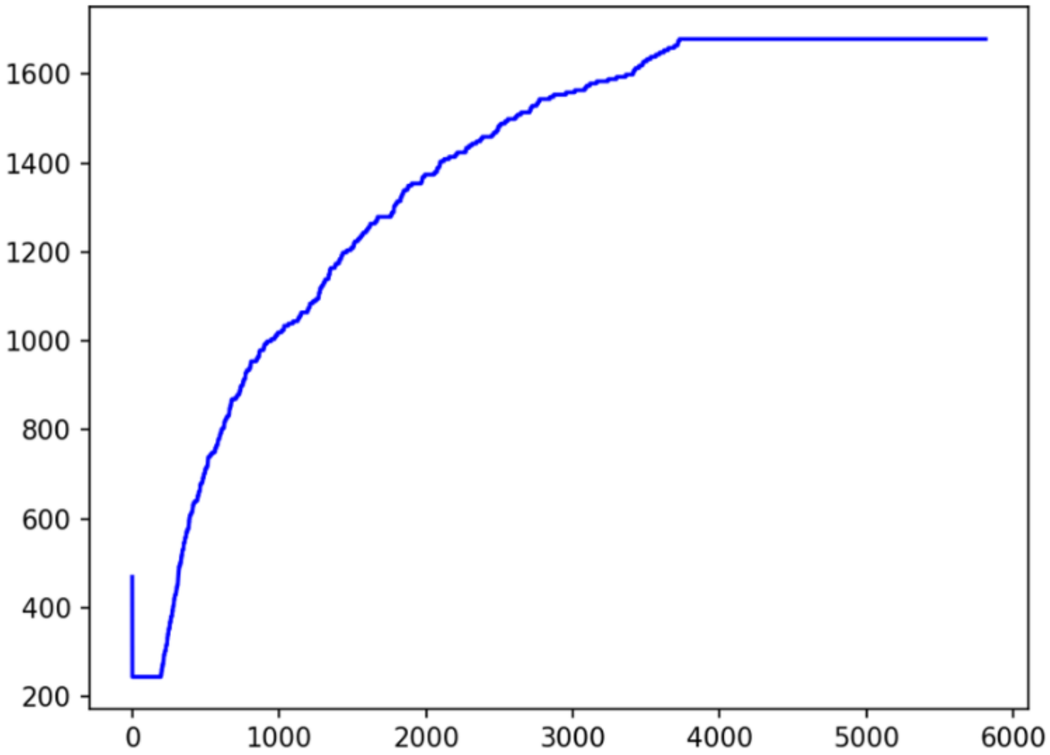


Percentage of people infected, portion of elders infected,
portion of adults infected

RESULTS

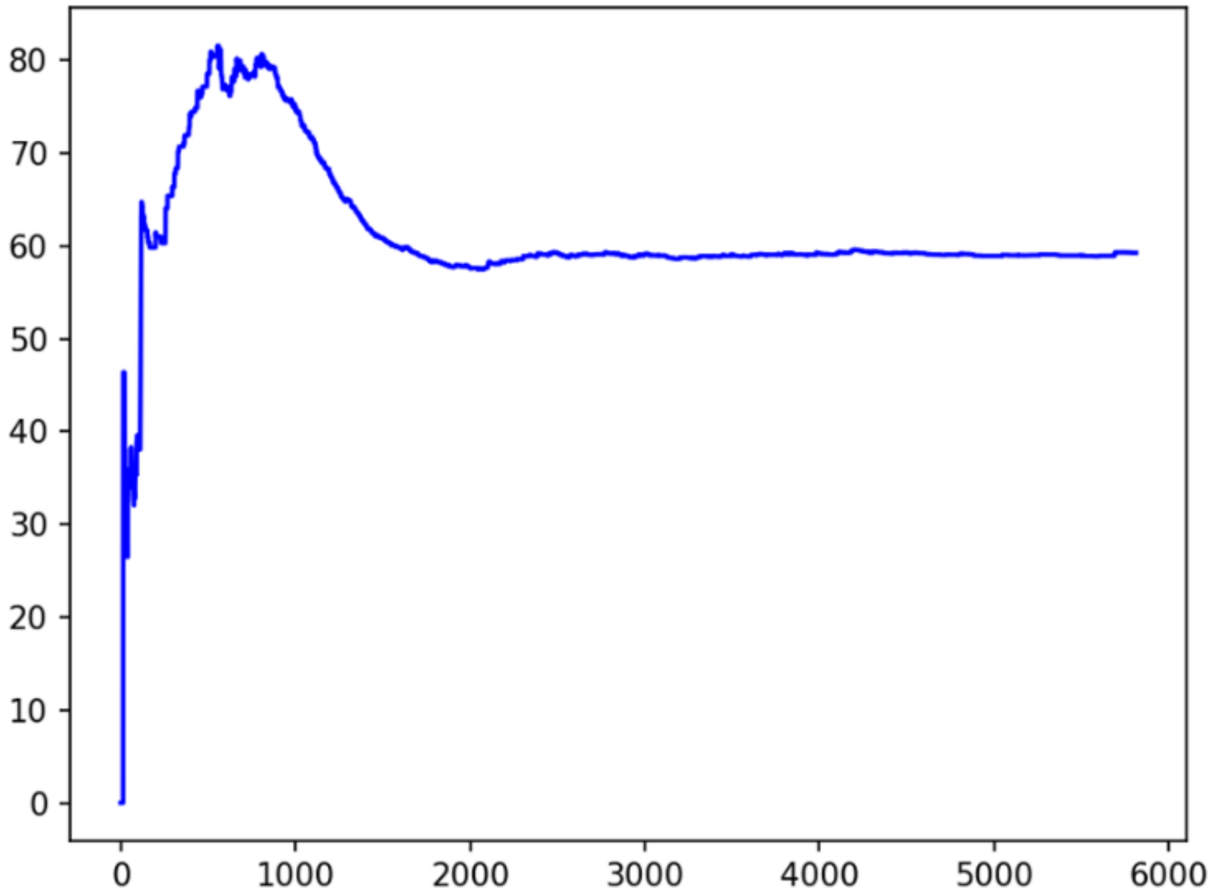


number of hospital



number of tpg stops

RESULTS



Average of the time to go to the hospital

STRENGTHS

- Despite initial delays, the experiment ultimately yields the anticipated results.
- Individuals are categorized into two distinct groups, enriching the simulation's complexity.
- Numerous interactions are accounted for, enriching the model's fidelity.
- Structured data underpins the model's integrity.

LIMITATIONS

- The model's portrayal of environmental reactions may lack realism due to lack of validation.
- TPG stop agents lack a maximum capacity. In the initialization, some TPG stops were removed to simplify.
- Simplified disease transmission dynamics may limit the model's accuracy in representing real-world scenarios.
- Limited consideration of socio-economic factors and behavioral changes during disease outbreaks may oversimplify the modeling of dynamic systems.

- Homogeneous behavior and interaction patterns among people may not capture the diversity of human behaviors.
- Lack of consideration for geographical variations may affect the model's generalizability.

RECOMMENDATIONS FOR MODEL IMPROVEMENT

Refine Disease Dynamics:

- To enhance the realism of the model, we suggest incorporating different stages of infection and symptoms and recovery.

RECOMMENDATIONS FOR MODEL IMPROVEMENT

Enhance Individual Behaviors:

- Incorporating preventive measures such as social distancing and mask-wearing in the decision-making process made by agent can provide accurate results.

RECOMMENDATIONS FOR MODEL IMPROVEMENT

Consider Agent Diversity:

- To better reflect the diversity of the population, consider simulating more age groups, geography, socioeconomic statuses, and real health conditions among individuals. Including attributes such as vaccination status and susceptibility factors can provide a more comprehensive understanding of the impact of the epidemic on different demographic groups.
- Exploring family factors' influence on disease spreading patterns to enhance model sophistication.

THANK YOU FOR YOUR ATTENTION