UNIVERSITÀ
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DI TORINO

Computer Science Department

An agent-based decision support for a vaccination campaign

Emilio Sulis, Pietro Terna

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An agent-based decision support for a vaccination campaign

topics covered in this presentation

Motivation
Agent-based business processes simulation
AI techniques for decision making
ABM case study: Piedmont Region
First results
Future work

An agent-based decision support for a vaccination campaign

Motivation

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MOTIVATION

- Practical application in the context of 2020 pandemic emergency
- Agent-based business process simulation (organization, BPM, and complex systems)
- Exploit Agent-Based Modeling (ABM) for decision-making
- AI techniques applied to ABM

An agent-based decision support for a vaccination campaign

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Agent-Based Business Process Simulation

- **Business Process Management** to support organizations
- Healthcare Process **Simulation**
- **AI techniques** applied to an ABM

Agent-based modeling and healthcare processes

> Why agent-based perspective?

1. Improve the **understandability**/immediateness for not specialists (e.g., visualization of actors movements)

2. Attention to agents **interactions**/**robustness** to changes

3. Exploring interactions between **micro-macro** level

Agent-based modeling and healthcare processes

Interactions between agents behaviour and environment

> Complexity

> Non-linear interactions

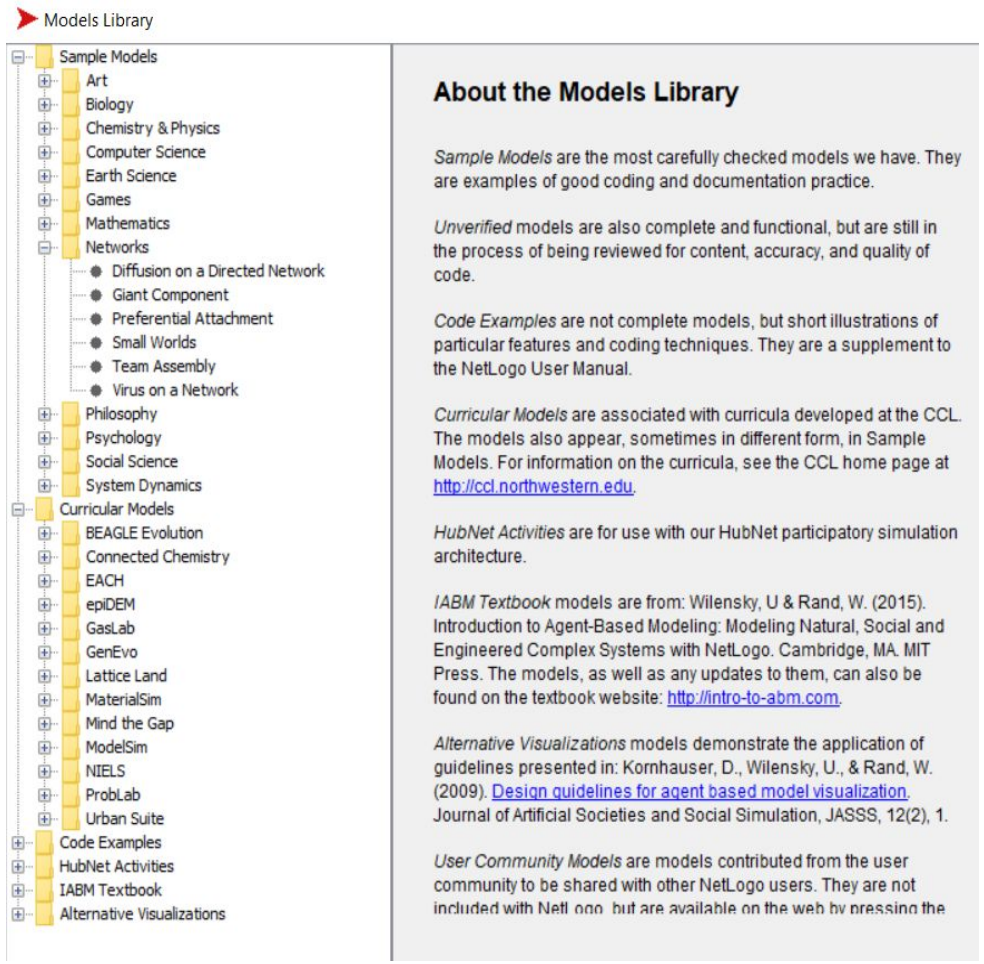
> Emergent behaviour

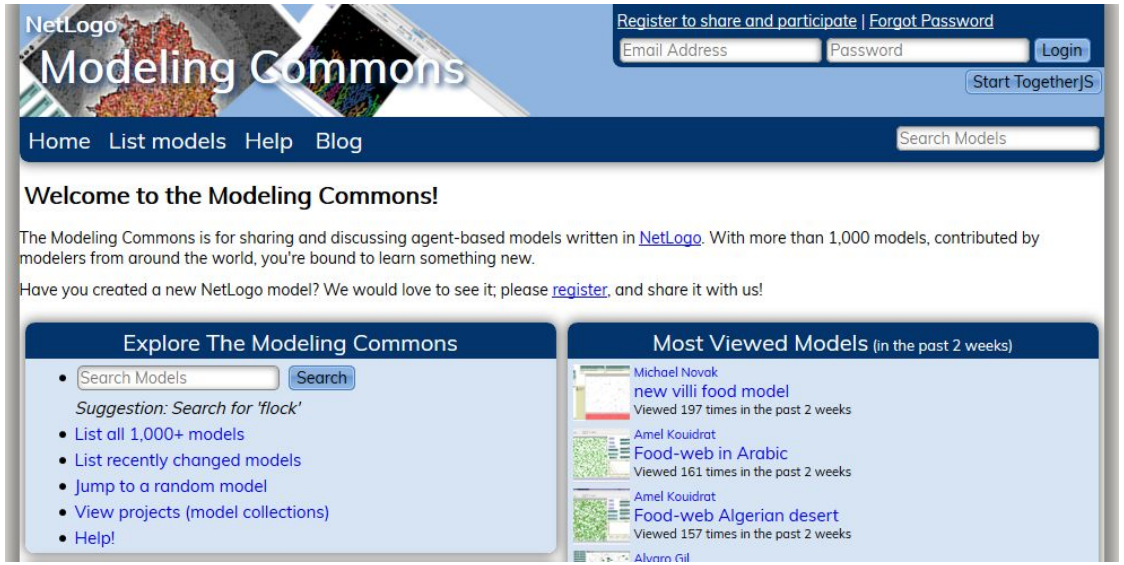
>>> Agent-Based Modeling [*NetLogo*]

Why NetLogo ?

- The **capability** of managing collection of (instances of) ‘agents’
- BehaviourSearch tool to perform **Genetic Algorithm**
- The **graphical representation** of the agents' world
- Its **openness**, also in a web-based version, it’s easy to connect to R or Python, extend with GIS or SNA libraries, or to build new extensions written in Java or Scala.

NetLogo: FOSS and community support





CoMSES NETWORK | OpenABM

WEST BIG DATA INNOVATION HUB

Computational Model Library

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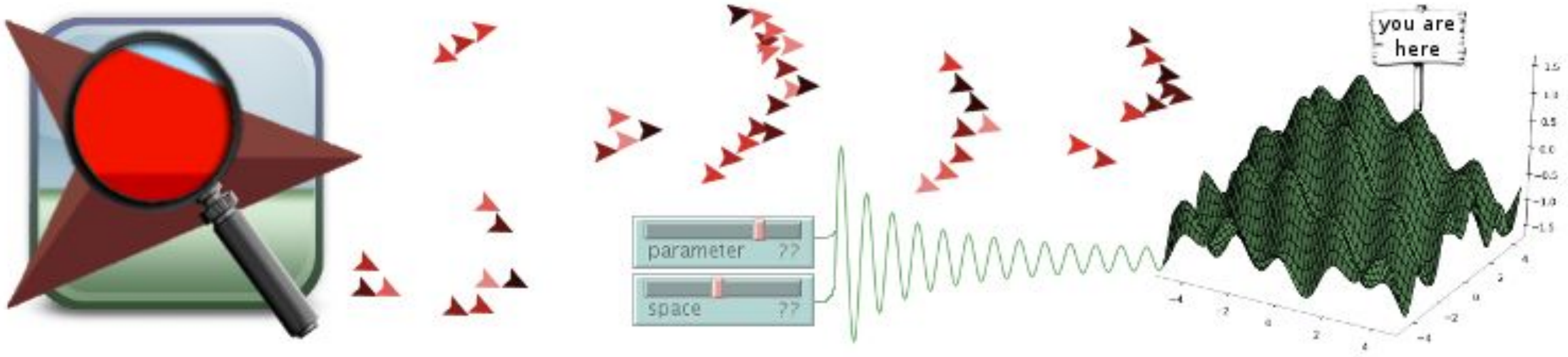
Genetic Algorithm

- GA is a search heuristic to solve an optimization algorithm reflecting the process of **natural selection**
- “survival of fittest”: the **fittest individuals** are selected for reproduction of a new population
- crossover (recombination): to combine the genetic information of two parents to generate **new offspring**
- **iterative** use of genetic operators on individuals in the population

BEHAVIOR SEARCH

A software tool to help with automating the exploration of ABMs

Genetic algorithms (and other heuristic techniques) to search the parameter-space.



https://www.behaviorsearch.org/

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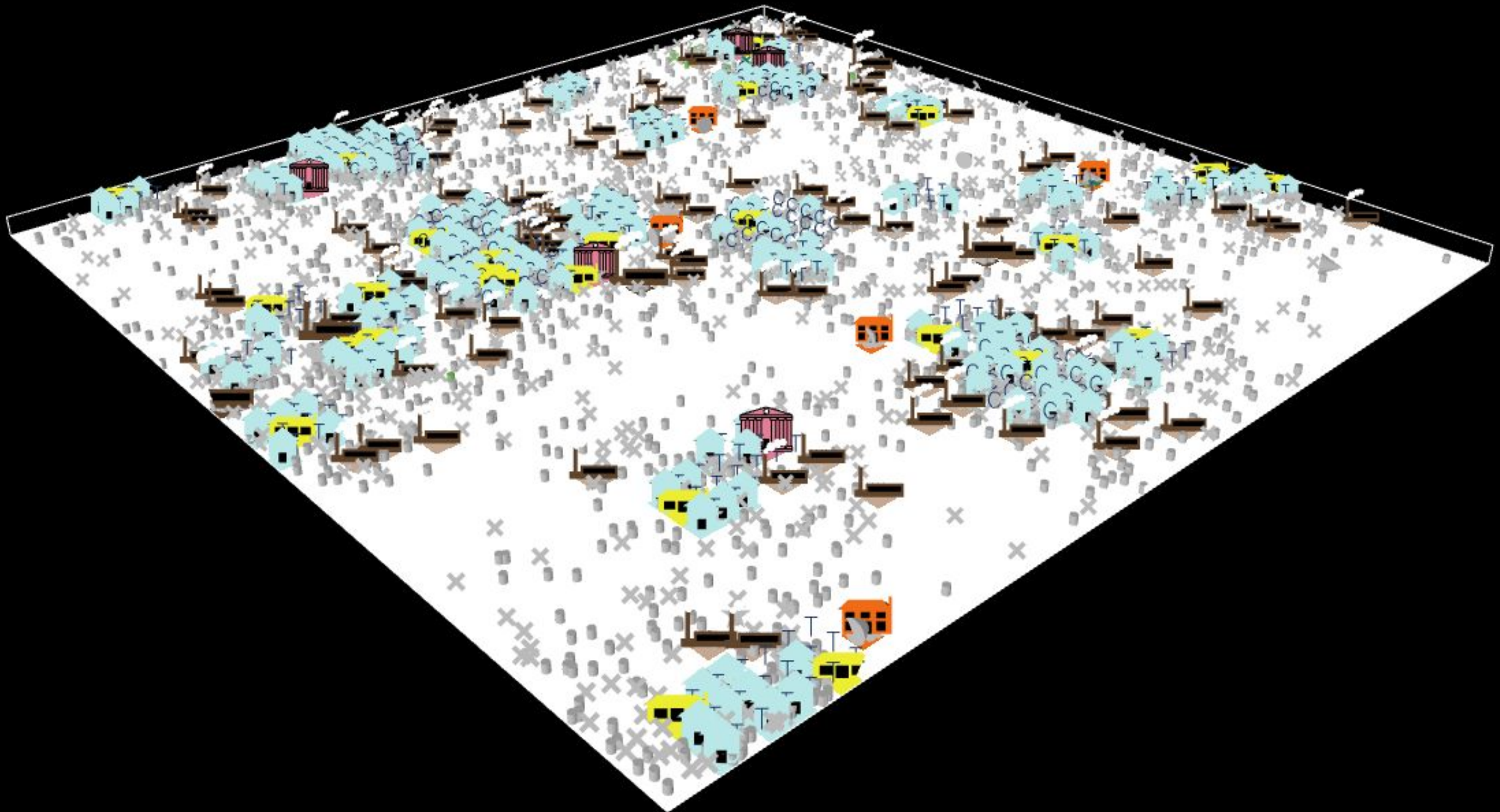
S.I.s.a.R. model

- Piedmont population - scale 1 : 1000 (4,350 agents)

- Four types of agents:
  Susceptible, **Infected symptomatic**, **Infected asymptomatic**, **Recovered**

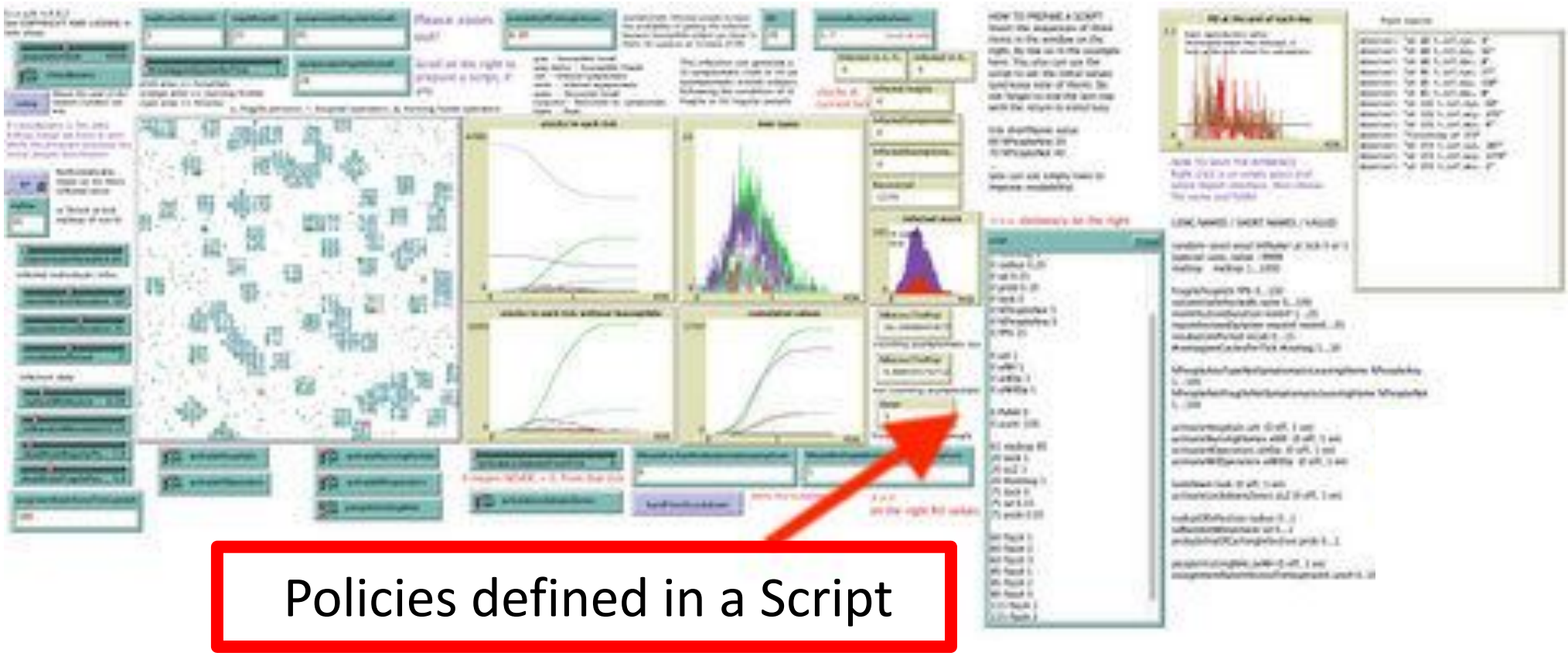
- Agents movements:
  - The **virus diffusion** among different hosts
  - The interactions between individuals in **different environments**,
    e.g. houses, schools, hospitals, nursing homes, factories

- Web-site of the Model: https://terna.to.it/simul/SIsaR.html
  You can run the model **directly online**
  or download *SIsaR_0.9.5.4.2.nlogo* and run it locally with **NetLogo**.



S.I.s.a.R. model

- A realistic set of political interventions (e.g., national and local government decisions) can be defined in a **Script** in the interface



Vaccination campaign

General accepted idea: the **administration of the vaccine** to people can be helpful to **prevent infections**.

A **vaccination campaign** makes it possible to immunize people.

The vaccine is **not immediately available** to the whole population.

Vaccination campaign

The current simulation introduces such **vaccination strategies** as a public health policy intervention.

A choice has to be made about **which parts of the population** to vaccinate first, as a matter of **health policy**.

AI and ABM: experiment with **GA to suggest the best parameters** in performing a vaccination campaign based on the S.I.s.a.R. model.

Experiments

A GA algorithm defines the percentage of groups to be involved first.

Scenarios:

- ***baseline***. Nothing is done to avoid the virus diffusion

Similarly to Italian government vaccine campaign, 2 scenarios:

- ***immuneInfecting***. Once agents have become immune they can be contagious.
- ***immuneNoInfecting***. Agents immune are not contagious.

GA parameters

The GA parameters setting concerns the **percentage of people** to be vaccinate in each round of the campaign.

The population can be divided into **categories of interest (groups of people considered in the experiments by age or by type)** for the implementation of vaccinations.

BehaviourSearch tool to explore GA, with a limit of 300 runs.

GA parameters

Group	Description
g1	Three sub-categories related to nursing homes: i. health fragile people in nursing homes ii. nursing home operators iii. healthcare operators
g2	Teachers of public and private schools
g3	Workers with medical fragility
g4	Plain workers
g5	Fragile people without special characteristics
g6	Regular people not young not worker not teacher
g7	Young people excluding special activity cases

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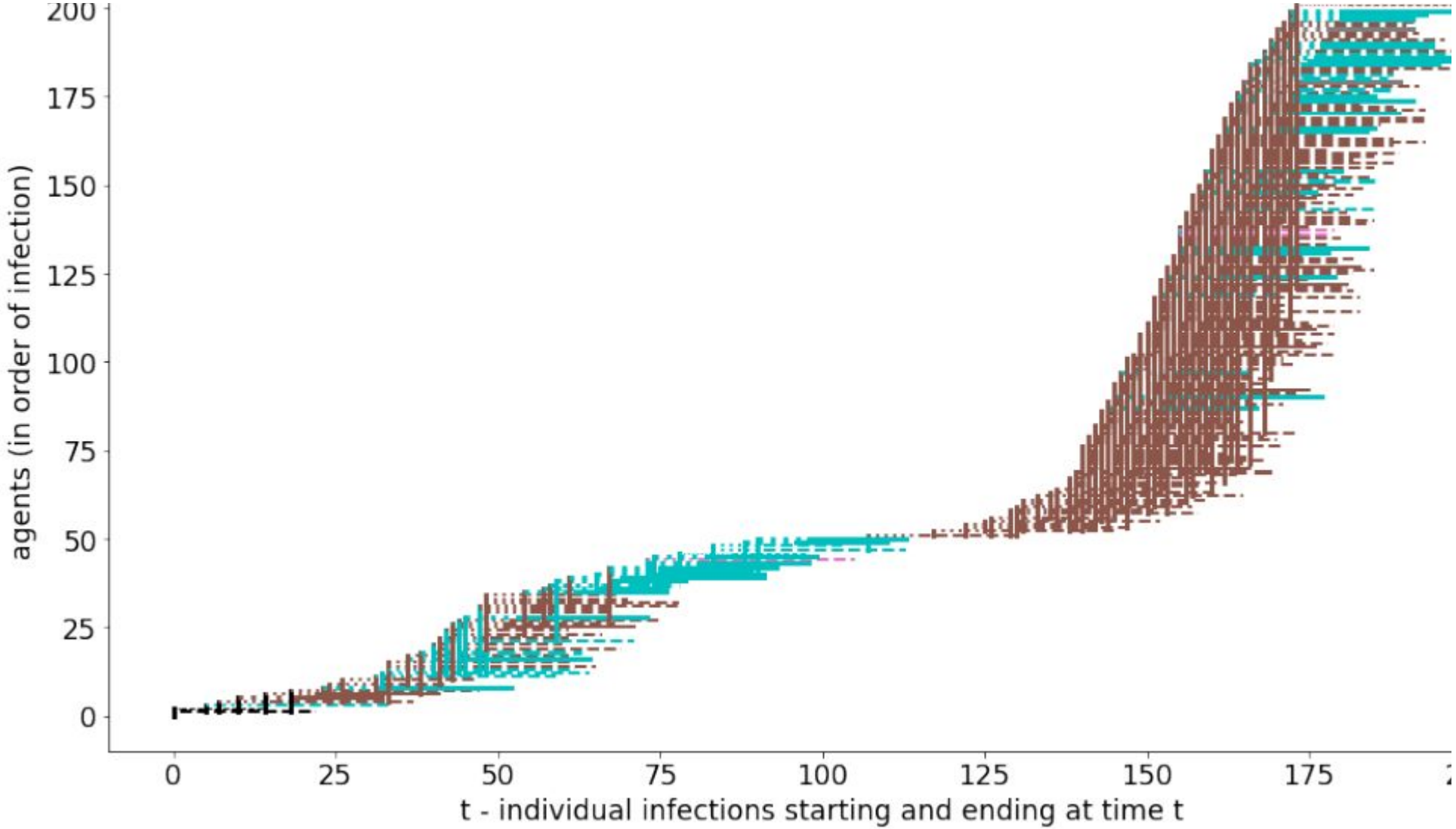
First results

The **number of the infected agents** at the end of the simulation:

- *baseline* (the model without any vaccination campaign): 325,000 infected [7.5% of the whole regional population]
- *ImmuneInfecting*: more than 215,000 infected
- *ImmuneNoInfecting*: more than 200,000 infected

First results



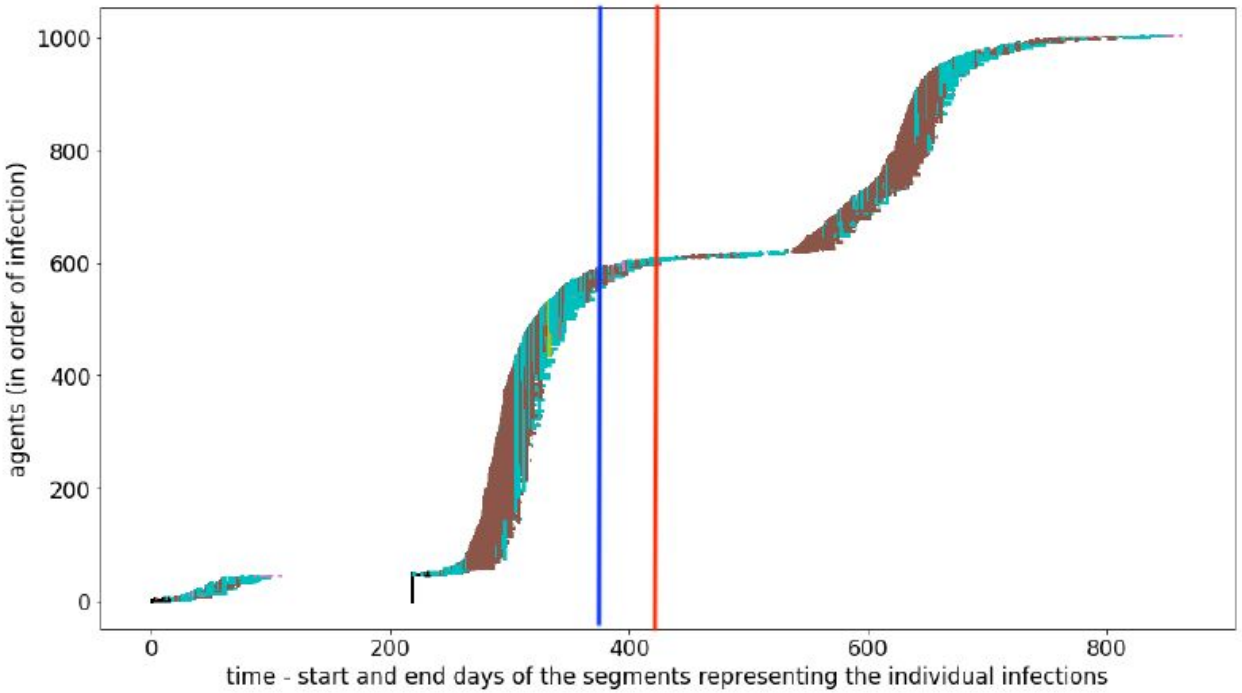
First results

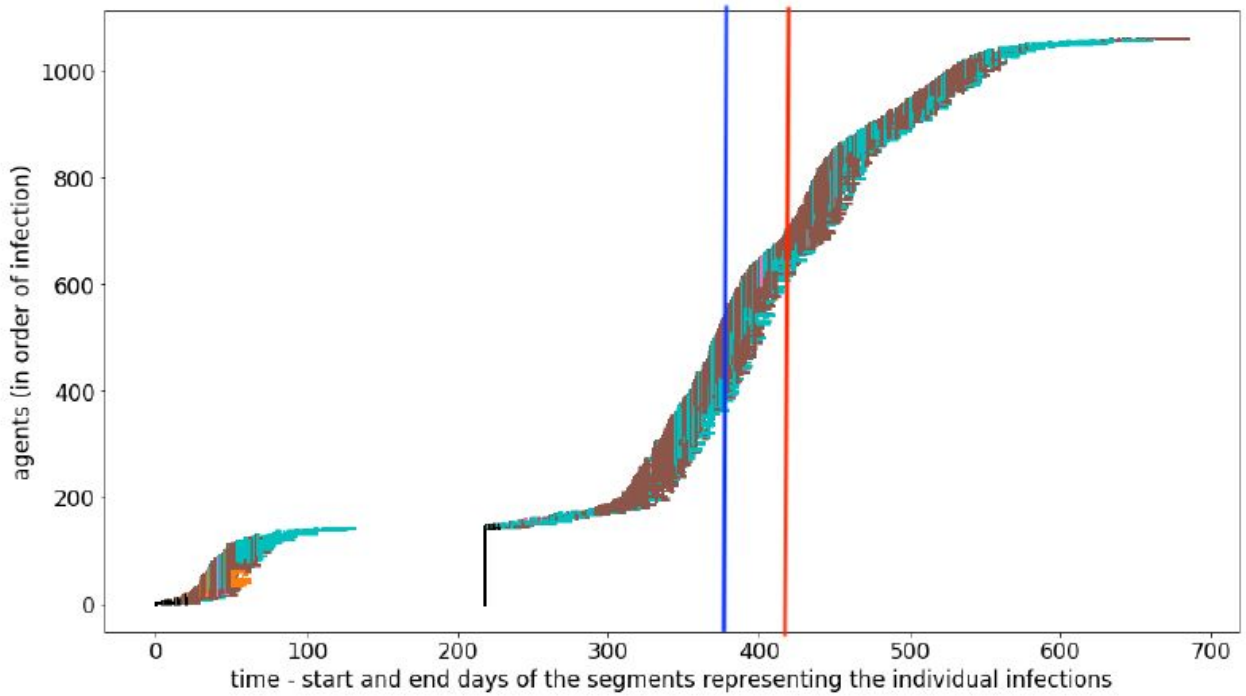
We compare the effect of choosing the vaccination quotas via GAs with two predetermined strategies in *immuneInfecting* and *immuneNoInfecting*

- Key dates:
  - in the calendar of the model Feb. 12th, 2021 is effectively the starting point of the vaccinations in the region (day 373 in the model);
  - the **day of the effectiveness** of the initial vaccinations is Mar. 22nd, 2021 (day 413) i.e. 40 days later the starting day of the vaccination.

First results

Two experiments results

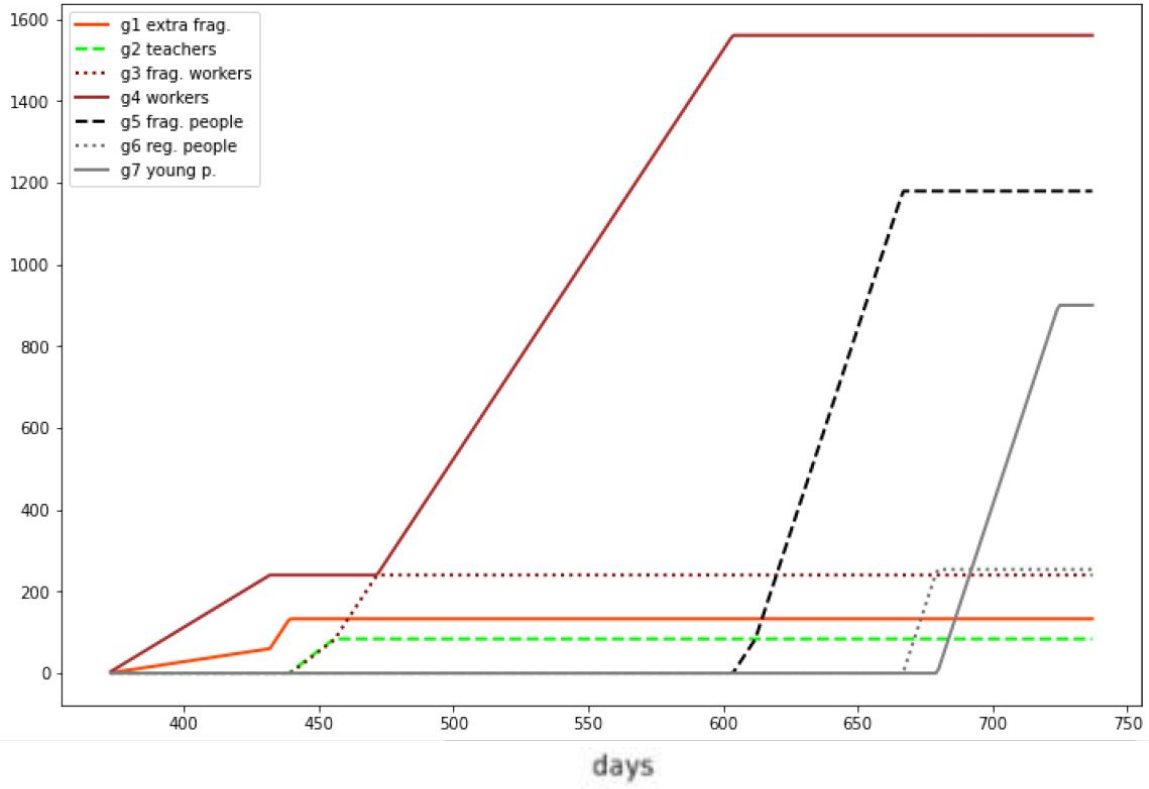




Vaccinated people still spreading the infection

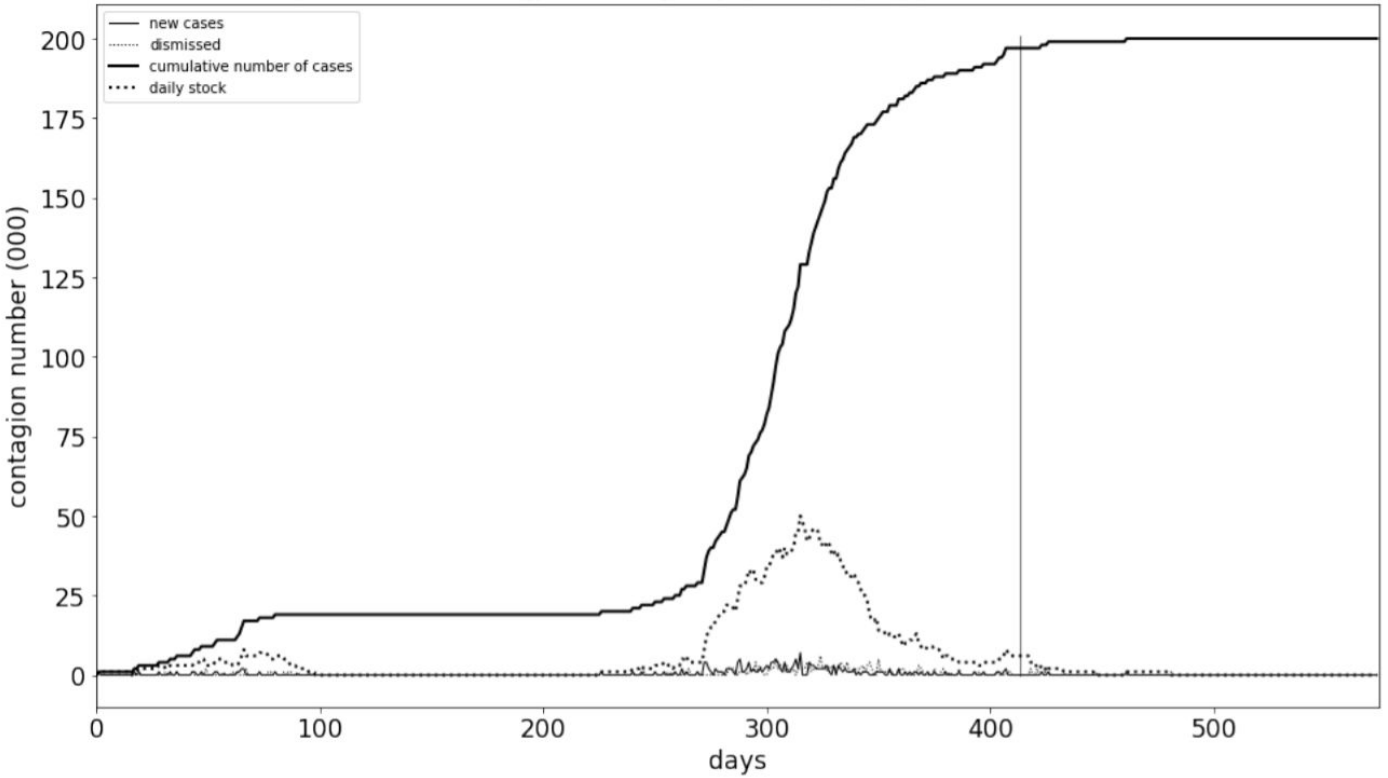
The **vaccination sequence** for each group

y axis: n°of vaccinated subjects



[if vaccination is complete: horizontal line]

y axis: n°of contagions



[vaccination symptomatic series]

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Future work

We aim:

- to improve the experiments by using an HPC platform
- to explore the results under scenarios:

Lockdown. A more restricted scenario for fragile people and workers

immuneInfecting50. Once agents have become immune they can be contagious at random (50% of cases)