# EpiDEMExtended report

## Introduction

EpiDEMExtended is a model created to simulate the spread of a pandemic in a population at the variation of different parameters. The model is implemented in NetLogo and is an extension of epiDEM Basic, one of the library models that come pre-installed with NetLogo. EpiDEM Basic simulates a SIR (susceptible-infectious-recovered) epidemiologic model (once someone has recovered, he/she is completely immune from the disease) in which individuals move around randomly and infect each other when close enough. This base model allows to vary the size of the population, the probability of getting infected when close enough to an infected individual, the average time needed for recovery, the probability of recovering after that time (at each time unit following the end of the recovery time, the model keeps extracting a random number and checking whether it satisfies the probability. Only when it does the person has actually recovered). Regarding the output the model produces, three plots are generated: the cumulative infected and recovered (cumulative since it keeps track of everyone that ever got infected, even if now that someone has recovered), the number of infected and not infected in the population, the infection and recovery rates. It is also calculated an estimate of the basic reproduction number, R0, which is the number of people infected by a single individual inside a fully susceptible population. This number is rather important since if R0 > 1 then the disease tends to become a pandemic, if R0 < 1 then the disease tends to disappear.

EpiDEMExtended starts from here, adding various elements to the model. In the next sections (o questa per la descrizione ad alto livello?) of this document these elements will be described, first in a high level, global way, and then more specifically regarding the implementation.

## High level model

EpiDEMExtended presents different types of agents who partake in the simulation:

* Activities -> immobile agents, comprising all various activities that individuals may do during the day, both dutiful (jobs, going to school) and recreational
* Houses -> immobile agents, each representing the home of a certain family
* People -> the individuals, (mostly) moving agents divided into age classes and grouped into families

Activities are furtherly divided in 4 sub-groups:

* Leisure activities -> all the recreational activities people will do after their duties. This includes parks, cinemas, restaurants etc. Note that each of these activities will also be a workplace for some people
* Education activities -> any teaching activity falls here. Schools and universities are part of this category. Again, note that for some people these activities will be their workplace
* Health activities -> hospitals, clinics, chemist’s and such are part of this category
* Professional activities -> all other work-related activities that are not part of the other groups (banks, post offices, factories etc.)

Activities are defined in files, specifying the kind of the activity (its description, basically), its productive value (economical importance of the activity) and its capability of smart working (how possible it would be to work from home). Regarding individuals, they are separated into 7 age classes, each of them presenting a different behaviour and susceptibility to the virus. The considered age classes are the following:

* 0-4 -> modelled to remain constantly home (may still get infected through the other family members)
* 5-14 -> attend the type of education activity in the simulation denoted as “primary school”
* 15-19 -> attend the type of education-activity in the simulation denoted as “secondary school”
* 20-24 -> attend the type of education activity in the simulation denoted as “university”
* 25-39 -> young workers, to each of them is assigned as a job one of the activities
* 40-64 -> old workers, to each of them is assigned as a job one of the activities
* 65 and older -> elders, who do not work but only enjoy recreational activities

The percentage of each class can be specified from file. As already stated, people are grouped into families. By family is meant a group of people (of appropriate age classes) living together in the same house. The grouping in families and subsequent house assignment is done following some rules. First of all, families have at most 4 people, of which at most 2 are sons (these two rules may not always hold, more details later in the implementation description). People aged 0-4, 5-14, 15-19 always live with two parents (0-4 with 25-39 parents, the rest with 40-64 parents), while 20-24 people may live with parents 40-64 or with a roommate (another 20-24) or alone. The remaining age classes may live with another person of the same age class or alone. All these possibilities can be made more or less probable defining from file percentages for them to happen, along with the probability for any individual of one of the “son” age classes to have a sibling in the same age class.

Now that a description of the parts of the model has been addressed, let us move to the behaviour of agents during the simulation. As already told, the only moving agents are people. The individuals (except 0-4 people, who, again, just stay home) move depending on a cycle appropriate for the age class they belong to, cycle that can be specified from file (being cycles completely configurable, the responsibility for them being actually appropriate is left to the programmer). These cycles are made of activities that people will follow for a certain duration (defined as well from file). It is also possible to introduce variability of the activity performed for a certain time slice (more details in the implementation part). The defined cycles won’t always be followed though: this due to the presence of a variable, modifiable at runtime, that simulates a quarantine with different levels of gravity that, consequently, may keep an increasing number of activities closed, forcing individuals who wanted to do them to change plans. This will not always happen: an individual may, with a probability of 5%, decide not to follow the law and move normally anyway.

Now, regarding the disease transmission, individuals can get infected due to closeness with a sick person or through “environmental” infection (if activated by the user). Going in order, the infection due to closeness happens with a certain probability that differs for each age class and situation the person is in. The susceptibility (probability of getting infected) of a person of a certain age class in a certain situation is obtained by the mean number of contacts that age class experiences in that situation divided by the total mean number of contacts for that age class (data regarding the contacts has been obtained from a study conducted by the Italian Comitato tecnico scientifico, see the first table of <http://www.quotidianosanita.it/allegati/allegato1389403.pdf>). The different situations considered are being at home, being at school, being at work, being at leisure and moving to any target (= being outside). Each of them has a respective susceptibility in the proper age classes (a student doesn’t need a work susceptibility).

Moving to the other way of getting infected, by “environmental” infection is meant getting infected due to moving where an infected person has recently been, coming in contact with infected particles he left behind (by breathing, sneezing etc.). This happens only if the user wishes so, by activating a switch at any time before or during the simulation. There are two other related parameters that can be set: the infected particles decay time, since after a while those will evaporate, making passing through that particular point safe again, and the base environmental infection chance, the probability for a susceptible individual to become infected getting in contact with the infected particles. Note that this last probability is a base one, since it will be scaled down depending on how long the infected particles have been around (the “infectious strength” of the particles diminishes with time because of their evaporation).

Lastly, some outputs were added: five counters for the number of infected people in each situation (while at home, while at school, while at work, while at leisure, while moving) and an estimate of the global productivity, that changes as the quarantine level does, due to some activities being kept close (it is also shown the percentage of closed activities).

Now that the model has been described at high level, let us move deeper into some implementational aspects.

## Activities