Alberto Baldovino Enrico Girotti Mila Mattio

2013

What Health?

Introduction

The starting point of our simulation is health economy, a branch concerned with issues related to efficiency, effectiveness, value and behaviour in the production and consumption of health and health care. A first precise definition of health care was given in 1963 by Kenneth Arrow who tried to transform this not well know branch in to a specific discipline. In his definition he gave result to those aspects that distinguish health from the other goods (in particular private goods); these factors are basically extensive government intervention, asymmetric information, uncertainty and externalities.

Health care is demanded as a mean for consumers to achieve a larger stock of "health capital". Health is both a consumption good, yielding direct satisfaction and utility, and an investment good, which yield utility indirectly (for example, fewer days of sickness means higher wages).

Even if this branch has to do with a particular kind of good, the main concern of economists has always to do with costs. Health economists evaluate multiple types of financial information: costs, charges and expenditures. In this work, we will focus our attention on the costs that arise when patients move from different hospitals. It is not surprising that such kind of costs exists. Patients, especially those that are affected by malignancies, tend to "experiment" different hospitals searching for better cures. These movements generate various types of costs, both economic and social costs.

Patients' movements can be of two different types: movements in the same region and movements outside the region. We will focus mainly on the former and only partially on the latter.

The Simulation

The objective of our simulation is to analyse the different variables that we think that affect these movements. Studying the simulation we will try to understand the *behaviour of the patients to see if the movements follow some logic and which are the variables concerned.*

The work will be developed using Netlogo 5.0.3.

The World

Our environment is specific: we will try to study this phenomenon in Piemonte.

The origin will be located in the corner on the bottom left. There will be 8 main centers: Alessandria, Asti, Biella, Cuneo, Novara, Torino, Verbania and Vercelli. The centres will be set according to the geographic coordinate.

In the neighbourhoods of each city centre we will set the different hospitals, characterized on the basis of the dimension (bed seats).

The Agents

The agents of our simulation are the cancer patients, who will be organised in 4 different classes according to their age. The reason is that empirical evidence shows that the youngest patients tent to move more than the old ones.

Breakpoint

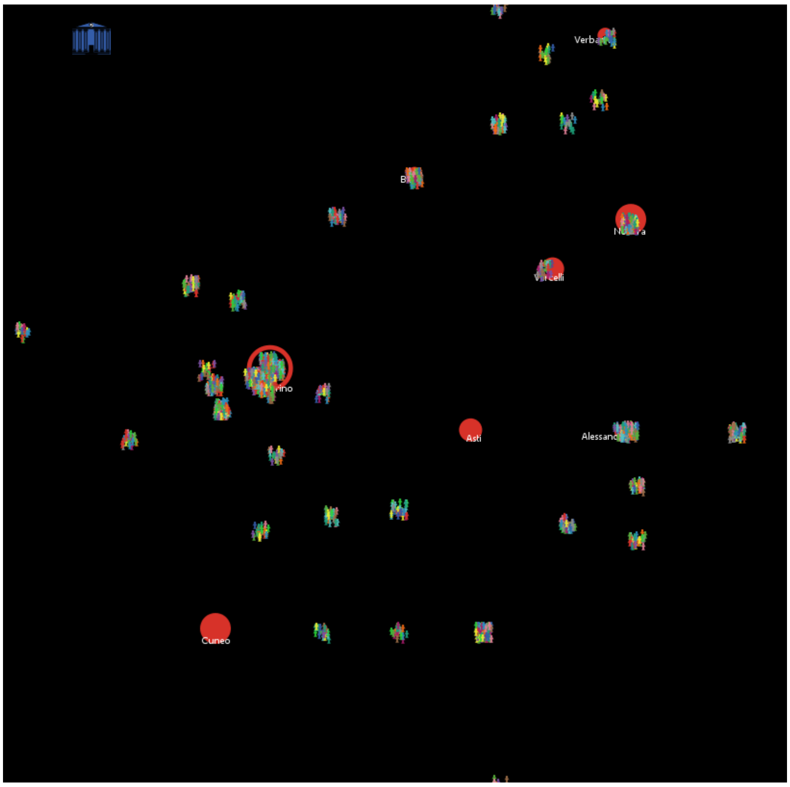
After studying the movements in the original setting we imagine to change the world. First we will imagine to reduce the number of bed seats in each hospital in order to recreate an hypothetical cancer ward. Then we will consider also the patients' movements to hospitals that are not in Piemonte.

Conclusion

Finally we will report the results, having attention to underling the differences occurred after the change in the setting. From the empirical evidence we will then try to imagine at some solutions that may improve the system.

The World

We start our simulation by creating the world in which the agents will act.



First we have modified the setting's dimension: the origin is in the corner on the bottom left and the maximum x and y coordinates have been enlarged (both take value 100) and the patch size has been modified to 8.

Second, through the setup button, we have located the most important cities with their precise coordinates, in order to give the map a sketch of representation. The cities have been created using a breed instead of a patch. To simplify our work we have adopted a rule for using correctly the coordinates in the modified space. For the longitude we considered a range of (8-6) degrees (our x variable), while for the latitude a range of (46-44) degrees (our y variable). Then we have converted the data in order to be comparable with the dimension of the world.

Ex. Asti:

- Take the difference between 46 and the real coordinate, 44,91
- Take the difference between 2 (the length of the range) and the value you get in the previous step, 1,09
- Then take the proportion: 1,09 : 2 = x : 100
- Same thing for longitude

```
    ask city 0
[set color red set label "Asti" set shape "circle" set size 3 setxy 60.3025 45.2625]
```

Third, we have represented the hospitals, again creating the corresponding breed. As for the cities, also the hospitals have been located according to their precise coordinate (adjusted according to the above rule).

```
    ask hospital 10
  [set color green set weekly_recoveries 72 set seats 748 set shape "building institution" set size1
setxy 33 51 ask patch-here  [sprout-patients 72 [set nowHospital 10]] set pole 1]
```

The most important thing to say is that we have not represented the overall number of hospitals but we have considered a partition of them. Each hospital is created with a number of precise features: the size, the number of beds, the weekly recoveries, the pole. The fact that all the hospitals (in the number of 40) have been divided in 8 different poles enable us to construct a matrix, reporting the probabilities according to which the patients move:

```
    set probabilities [ [ 0 0.008 0.01 0.013 0.014 0.016 0.102 0.112 ] [ 0.098 0.098 0.101 0.102
0.102 0.108 0.141 0.141 ] [ 0.048 0.049 0.049 0.052 0.06 0.067 0.074 0.075 ] [ 0.016 0.018 0.021
0.021 0.037 0.037 0.041 0.041 ] [0.074 0.076 0.089 0.159 0.159 0.16 0.169 0.177 ] [ 0.144 0.169 0.29
0.294 0.296 0.296 0.341 0.374][0.457 0.477 0.479 0.481 0.481 0.483 0.483 0.488 ] [ 0.543 0.546 0.558
0.564 0.577 0.578 0.653 0.653 ] ]
```

With reference to the different pole we have that:

1. Pole 1 → hospitals in Turin
2. Pole 2 → hospitals in the South ex. Cuneo
3. Pole 3 → hospitals at the right of Turin ex. Casale Alessandria
4. Pole 4 → hospitals in the North ex. Domodossola Verbania
5. Pole 5 → hospitals a bit in the North of Turin ex. Vercelli, Biella
6. Pole 6 → hospitals in the area of Asti
7. Pole 7 → hospitals close to Turin (north-east) ex. Orbassano
8. Pole 8 → hospitals close to Turin (north-west) ex. Ivrea

Finally we have created the patients. The agents are created in the different hospitals according to a certain probability, using the command “sprout”. The number of agents created in each hospital differs: not all of them have the same dimension and importance. As already said the patients are divided according to different classes of age:

```
to setup-patients
      ask patients with [ let r random-float 1
    if r <= 0.0416 [set age 1]
    if 0.0416 < r and r <= 0.36 [set age 2]
    if   0.36 < r and r <= 0.86  [set age 3]
    if 0.86 < r and r <= 1  [set age 4]
    set shape "person"]
```

To consider the time dimension in our model we have set ticks; each tick correspond to a day and time stop after a year is passed.

The Agents

After having set the entire environment, we allow the agents for movement. Through the command “go” we allow them for the possibility of moving to different hospitals.

```
to go
  move-patients
```

They choose the destination using real data concerning the mobility: the movements between different poles and according to the various classes of ages.

They move following a specific rule: if their hospitalisation exceeds 5 days they move, otherwise they do not:

```
to move-patients
       ask (patients with [ nowHospital = hospWho and hospitalization >= 5 and ( (age = 1 and
random-float 1 < 0.5 ) or (age = 2 and random-float 1 < 0.28) or
         (age = 3 and random-float 1 < 0.17) or (age = 4 and random-float 1 < 0.05) )])
```

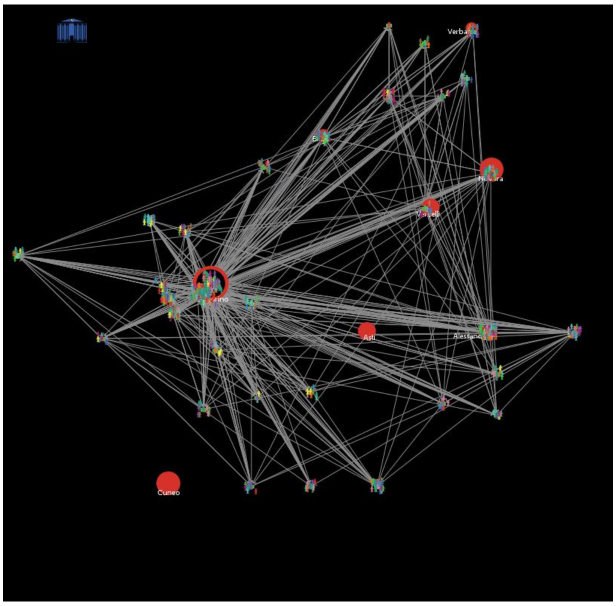
A specific feature of our model is related to the distribution of the hospitalization period. To represent it more precisely we have chose a Poisson distribution instead of a normal:

```
 set hospitalization (random-poisson 7.9)
set xcor ( xcor + random-float 2 - 1)
set ycor ( ycor + random-float 2 - 1)
```

Every week new patients are created in each of the hospitals. The number of new patients created equals the number of weekly recoveries. As time goes by patients go on moving to the different locations:

```
ask hospitals [
    let NewPatients weekly_recoveries
    let place who
    ask patch-here [
    sprout-patients NewPatients [set nowHospital place] ]
```

To make the movements more straightforward we use links between the patients and the hospitals. The patients' movements follows the direction of the arrow.

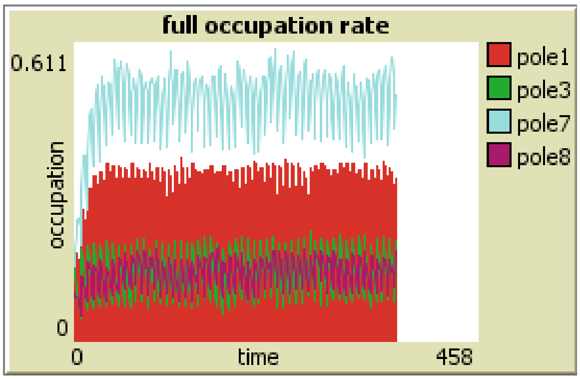


Tools

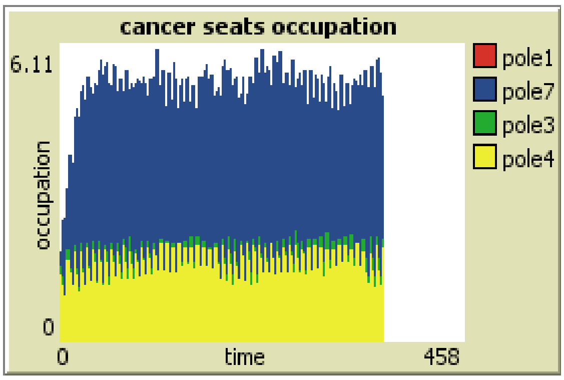
To make everything more evident we have used a set of graphical tools, including some monitors, two different plots and two switchers.

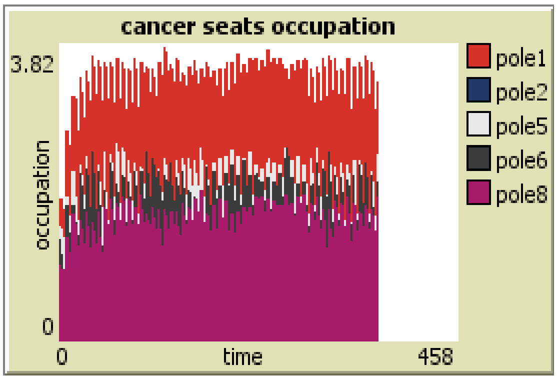
One monitor is used to count all the patients that move and the others show the specific patient flow to each of the different poles. Of course there is an evident huge difference between the patient flow related to pole 1(incorporating the hospitals in Turin) and all the others.

The first plot “full occupation rate” show the evolution over time of the occupation rate, given by the ratio between the number of patients and the number of seats. We have used the partition in poles and we have divided them in two different plots to avoid the possibility that some rates superimpose. In both we have represented the ratio for the pole 1 using it as a benchmark.



The second plot “cancer seats occupation” (again we have used two different graphs and the rate for pole 1 is used as a benchmark) reports the same ratio as the first plot, with the difference that we have considered only a reduced number of seats, only the 10%. In this way we can evaluate the occupation in each of the different pole.





Finally, one switcher is used to allow for the possibility that links disappear when patients stop moving, while the other is used to analyze the movements of the patients to hospitals that are not located in Piemonte. To do this we have created an additional hospital in the corner on the top left that represent all hospitals outside our setting. If we activate the switcher ("on") the model then also show the patients' movements outside the region. Simply looking at the links to this new hospital we see that these movements are as important as those inside the region.

Things to notice

Our simulation uses real data. All information related to the number of bed seats, to the weekly recoveries and to the partition of patients in different classes of ages are based on medical survey.

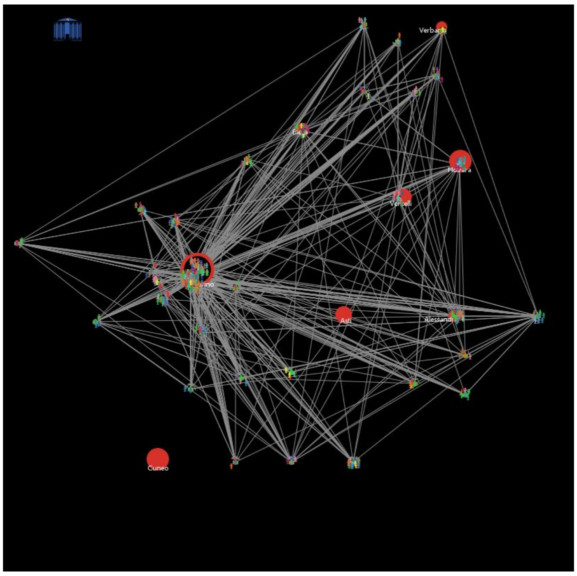
What is going on?

To make the results of our simulation more analytical we have considered three different dimensions:

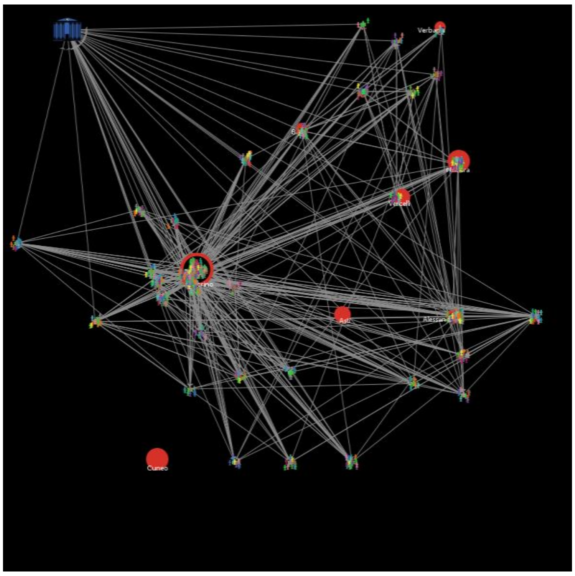
- General Mobility → first we have simply looked at the patients' movements to the different hospitals in Piemonte. It is immediate to notice that in Turin there is a tangle of links. In other words, the majority of these movements are in the direction of the main city. More in details, we observe that the patient flow is concentrated in the hospitals with pole 1, followed by those of pole 7. The reasons may be multiple: bigger and more specialized hospitals, more experienced medical staff. Patients that come to Turin are mainly those who are closer. The rationales may be of two types: first, the proximity to more well-known facilities (people have a preference for more specialized hospitals: the majority of hospitals around Turin have a great reputation) and, second, the fact that here generally live people who belong to the first class of age, which is that who move more. Differently, far from Turin, in the areas at the edge of our setting the movements reduce. As we move to centers that are far away from the main city we observe a great portion of people who belong to the last classes of age, who are effectively those who tend to stay where they are. This difference follows from a psychological tendency: young people are more motivated to find a cure and the fact that they show a lower degree of satisfaction both explain why they move more, whereas old people tend to be more resigned and move less. In addition, demography also exhibit that thickness is higher closer to the main centers. To make everything even more immediate we have realized a plot, "full occupation rate", that enable us to see which are the preferred pole. For occupation rate we mean the ratio between the number of patients and the bed seats in each of the pole. As you can image, those of pole 1 and 7 are quite similar, with a little higher rate for pole 1. All the other rate instead tend to be closer to zero. The meaning of these ratios close to zero is that patients rarely move in the direction of these hospitals.

- "Cancer Ward" → Looking at the general mobility we have considered the overall number of bed seats in the different hospitals and not only those that are reserved to cancer patients. In this second step we want to see what would have change to the occupation rate if we have considered only an hypothetical cancer ward. To do this we have reduced the number of bed seats in each hospital by 90% (the reason is that in general to these wards is dedicated one tenth of the overall number of bed seats). The outcome of this change in the setting is shown in the second plot, "cancer seats occupation". Again the occupation rate considered is given by the ratio between the number of patients and the number of bed seats in each pole. What differs is the number of bed seats: we can think of it as the bed seats that are exclusively reserved to cancer patients. The general trend shown in this second plot replicate that of the first plot, but with a different scale. The ratios can be divided in three groups with reference to their tendency: first, we have those for pole 1 and 7 that are the highest and almost superimpose; then, in the middle, we have those of pole 5, 6 and 8 and in the lower part those of pole 2 and 3. As for the general mobility, patients mainly go to the hospitals located in Turin or in the immediate corners.

➢ <u>External Mobility</u> → Our last focus has to do with movements of patients also outside Piemonte. The rational is that empirical evidence show that a great portion of patients also move in other regions. Since the data we have used report the general mobility, without making reference to the specific destinations, we have represented a unique big hospital that incorporate all these movements. To consider also this dimension we have created, as said before, a switcher:



Switcher "OFF"



Switcher "ON"

As we can observe from the picture above, if we take into account also the external mobility, we see that a great portion of movements are oriented outside Piemonte. More in detail patients from Alessandria, Novara, Domodossola tend to move to Milan and other facilities in Lombardia, while patients from Cuneo tend to move those that are located in Liguria.

Conclusion

The objective of our simulation was to analyze health mobility in Piemonte, with reference only to the cancer patients.

The main conclusions are :

- *Big hospitals are preferred to small ones*
- *The majority of movements is in the direction of Turin or in the immediate proximity*
- *Patients move a lot*
- *A great portion of movements is also directed outside Piemonte*
- *Young people move more than old ones*
- *Young people generally stay closer to the bigger centers, while old ones stay in the suburbs. This is the reason why the patients movements mainly come from area closer to the main centers.*