

# A Simulation Model for Understanding the Diffusion of the Pandemic

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with the determinant ideas of Gianpiero Pescarmona and the  
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Slides and project at <https://terna.to.it/simul/SIsaR.html>

YouTube channel:

<https://www.youtube.com/channel/UC31OBWUtgee7BQ7qQ3bqNeA>

# The S.I.s.a.R model

Susceptible, Infected, symptomatic, asymptomatic, Recovered

- Making the *invisible, visible*
- Analyzing the odds

*[using an agent-based model to cope with a complex phenomenon]*

## Preliminary note (1/3)

This is a simulation with random events, please do not take it as a sure forecasting machine; it is a *reasoning machine*, a sort of very complex "what if" mental experiment.

The New York Times offers us an analysis on the *The Covid-19 Riddle: Why Does the Virus Wallop Some Places and Spare Others?*

<https://www.nytimes.com/2020/05/03/world/asia/coronavirus-spread-where-why.html> (open link).

## Preliminary note (2/3)

In the web site of the model, we read:

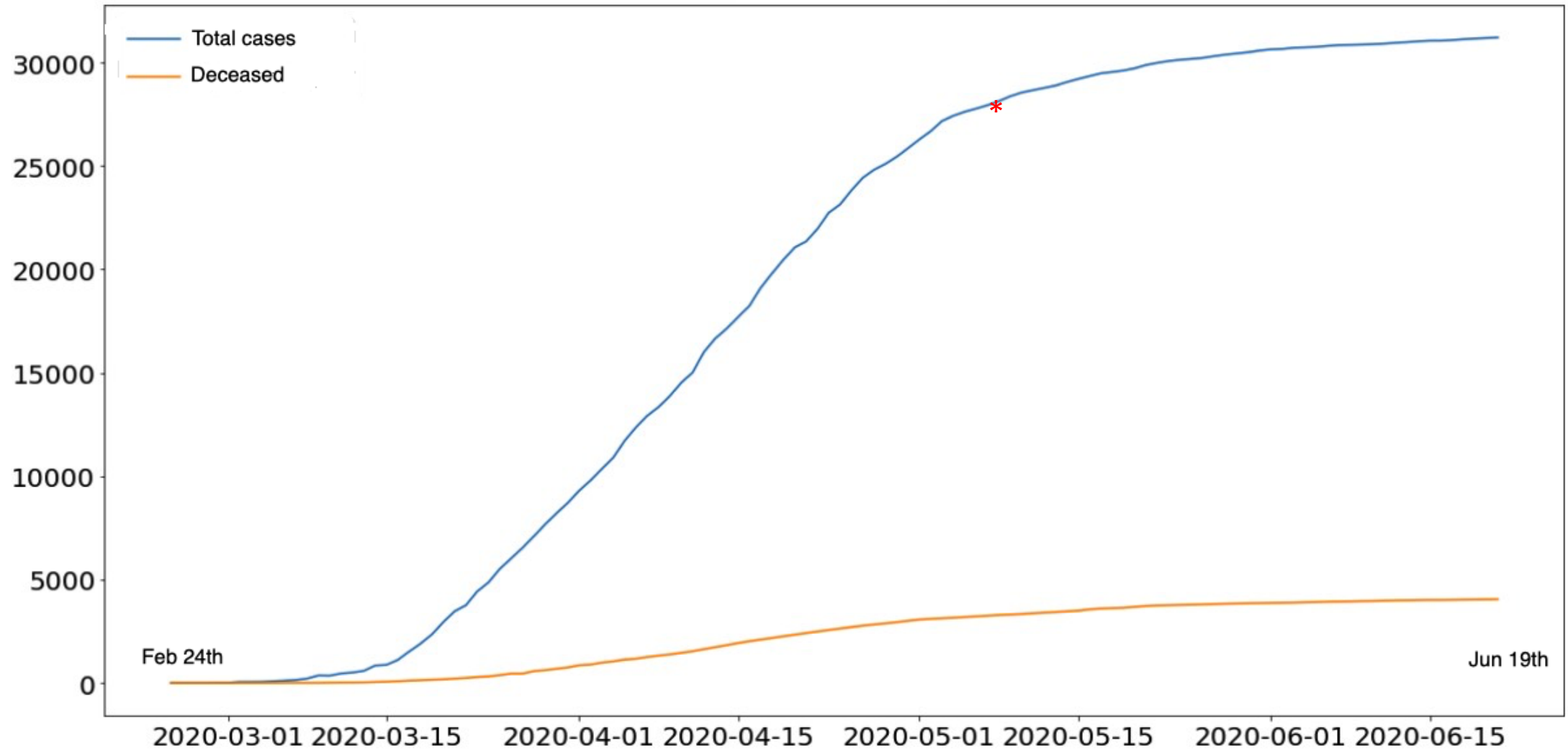
*Nota bene.* In each series of experiments, we will have variability in the results, although internally consistent. The model makes many agents act and interact; from the [complexity](#) point of view, each execution produces a "story," with a specific and unique sequence of emerging effects. Real events would behave in the same way if it were possible to repeat them.

## Preliminary note (3/3)

We can use the model in a comparative way, observing different ranges of results with different initial conditions and parameters.

Finally, to have a reference at an actual situation, the model is related to the Piedmont scale, with 4,350 agents vs. 4.35 millions of inhabitants. We look also to the time series of the total infected people in Piedmont (an Italian region).

# Piedmont, with a online [calendar](#) of the events



# The S.I.s.a.R model

as an agent-based model

**populationSize** 4350

On  Off **cities&towns**

**setup** About the seed of the random numbers see Info

If cities&towns is On, after hitting 'setup', we have to wait a few seconds while the program sets the initial people distribution

On  Off **myStop** Stops if no more infected exist or /pause/ at tick myStop (if not 0)

**peopleSize** Regular

**displayChoice** DisplayPeople

**ratioInitialInfected%** 0.05  
infected individuals infos

**minInfectionDuration** 10

**maxInfectionDuration** 25

**incubationPeriod** 7

**infection data**

**radiusOfInfection** 0.20

**sdRandomMovement** 0.30

**deadRateRegularPeo...** 1.0

**deadRateFragilePeo...** 9.9

On  Off **activateSchools**

**howManyClassroomsInASch...** 1

On  Off **activateFactories**

On  Off **fragileWorkersAtHome**

**healthcareOperators%** 1

**fragilePeople%** 35

**youngPeople%** 21

**#movementCyclesPerTick** 3

**Zoom OUT to see more widgets**

colors and their meaning  
 red - symp.; violet - asymp.; turquoise - symp. rec.; green - asym. rec. x, fragile persons; \*, hospital operators; Δ, nursing home operators

**asymptomaticRegularInfected%** 95

**probabilityOfGettingInfection** 0.05

**asymptomaticFragileInfected%** 20

**Scroll on the right to prepare a script**

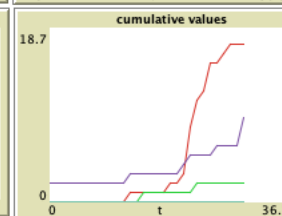
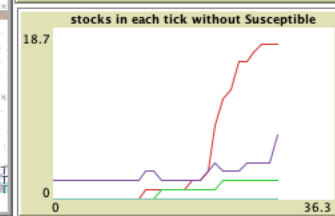
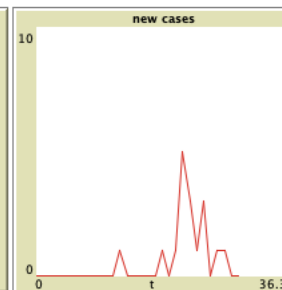
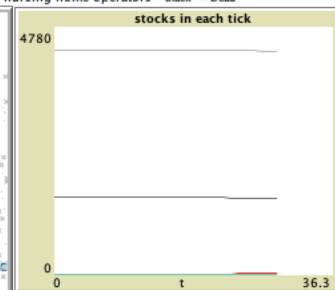
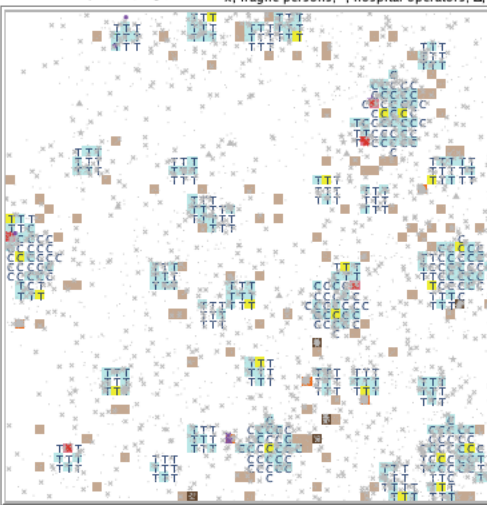
gray - Susceptible (total)  
 gray darker - Susceptible-Fragile  
 red - Infected symptomatic  
 violet - Infected asymptomatic  
 lime - Recovered (total)  
 turquoise - Recovered-ex-symptomatic  
 black - Dead

asymptomatic infected people increase the probability of getting the infection because Susceptible subject go closer to them; let suppose an increase of D%

D% -50

**intrinsicSusceptibilityFactor** 5 **look at Info**

The infection can generate a (i) symptomatic (red) or (ii) an asymptomatic (violet) subject, following the condition of (i) regular fragile or (ii) regular people



**Infected in n. h.** 0

**infected in h.** 17

**Infected fragile** 17

**InfectedSymptomatic** 17

**InfectedAsymptoma...** 7

**Recovered** 0

**Infected stock** 18.7 in each tick

**%Recov/TotPop** 0.045977011494252

also counting asymptomatic

**%Recov/TotPop** 0

not counting asymptomatic

**Deceased** 0

from symptomatic people

On  Off **activateHospitals**

On  Off **activateHOPerators**

On  Off **activateNursingHomes**

On  Off **activateNHoperators**

On  Off **activateBufferZones**

**activateLimitations/LockdownFromTick** 20

0 means NEVER; > 0, from that tick

**hardFinishLockdown**

**%PeopleNotFragileNotSymptomaticLeavingHome** 0

**%PeopleAnyTypeNotSymptomaticLeavingHome** 80

**%OpenFactoriesAlsoWhenLimitationsOn** 100

**>>> up on the right RO/Rt values**

**HOW TO PREPARE A SCRIPT**  
 Insert the sequences of three items in the window on the right, by row as in the example here. You also can use the script to set the initial values (and keep note of them). Do not forget to end the last row with the return (o enter) key.

tick shortName value  
 60 %PeopleAny 20  
 70 %PeopleNot 40

...  
 (you can use empty rows to improve readability)

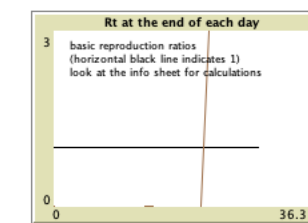
**>>> dictionary on the right**

**script**

```

106 flash 1
106 flash 2
106 flash 3
106 flash 4
106 flash 5
137 flash 1
137 flash 2
137 flash 3
137 flash 4
137 flash 5
167 flash 1
167 flash 2
167 flash 3
167 flash 4
167 flash 5
198 flash 1
198 flash 2
198 flash 3
198 flash 4
198 flash 5
229 flash 1
229 flash 2
229 flash 3
229 flash 4
229 flash 5
259 flash 1
259 flash 2
259 flash 3
259 flash 4
259 flash 5

38 aCP 1
106 aCP 2
198 aCP 3
259 aCP 4
  
```



**HOW TO SAVE THE INTERFACE**  
 Right click in an empty space and select Export interface, then choose file name and folder

**LONG NAMES / SHORT NAMES / VALUES**

random-seed seed anIntegerNumber  
 you can set the seed only at tick 0 or at tick 1 [special setting: value -9999  
 to have the system choosing internally the seed]  
 myStop myStop 1...1000

fragilePeople% fP% 0...100  
 youngPeople% yP% 0...100  
 ratioInitialInfected% ratio 0...100  
 minInfectionDuration minInf 1...20  
 maxInfectionDuration maxInf minInf...35  
 incubationPeriod incub 0...15  
 #movementCyclesPerTick #mov 1...10

%PeopleAnyTypeNotSymptomaticLeavingHome %PeopleAny 1...100  
 %PeopleNotFragileNotSymptomaticLeavingHome %PeopleNot 1...100

activateHospitals aH (0 off, 1 on)  
 activateNursingHomes aNH (0 off, 1 on)  
 activateHOPerators aHOP (0 off, 1 on)  
 activateNHoperators aNHOP (0 off, 1 on)  
 activateSchools aSch (0 off, 1 on)  
 howManyRoomsInEachSchool hMRs (1 or 2)  
 activateFactories aFac (0 off, 1 on)  
 %openFactoriesWhenLimitationsOn %Fac 0...100  
 fragileWorkersAtHome fWH (0 off, 1 on)

limitations/Lockdown limlock (0 off, 1 on)  
 activateBufferZones aBZ (0 off, 1 on)

radiusOfInfection radius 0...1  
 sdRandomMovement sd 0...1  
 probabilityOfGettingInfection prob 0...1

peopleVisitingNHs pvNH (0 off, 1 on)  
 assignmentRateInfectedToHospitals% assH 0...100

flash flash (1 t.inf.sym., 2 t.inf.asy., 3 t.inf.sym.NH, 4 t.inf.asy.NH, 5 t.dec.)  
 activateCheckPoint aCP (1 first, 2 second, 3 third, 4 fourth)

**Flash reports**

**seed (last one)** 22312

**Cumulative values from nursing homes**

**Infected symptomatic** 15

**Infected asymptomatic** 3

**Recovered ex-symptoma...** 0

**Recovered ex-asymptom...** 0

**Deceased** 0

**Cumulative values from teachers and**

**Sympomatic students** 0

**Asympomatic students** 0

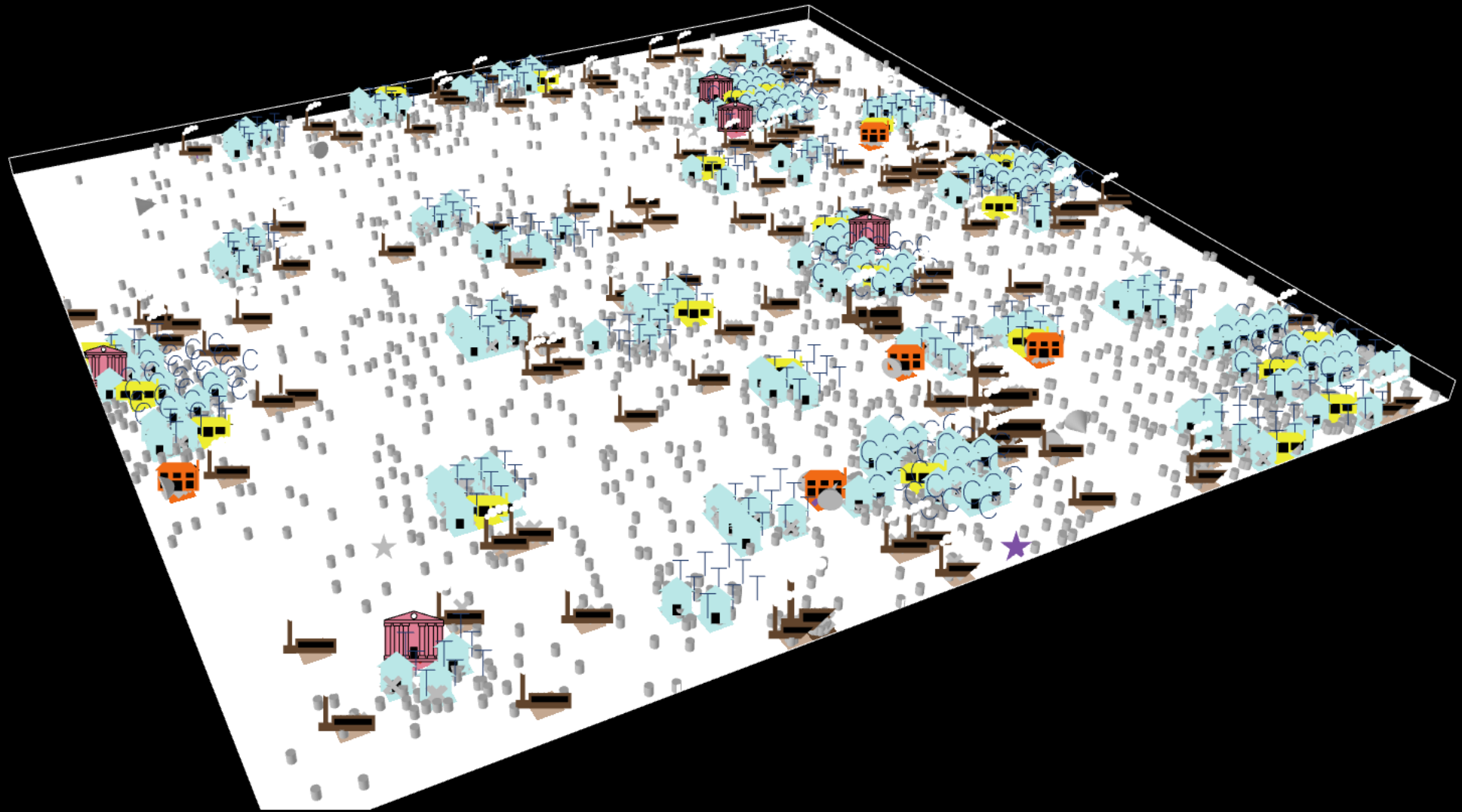
**Sympomatic teachers** 0

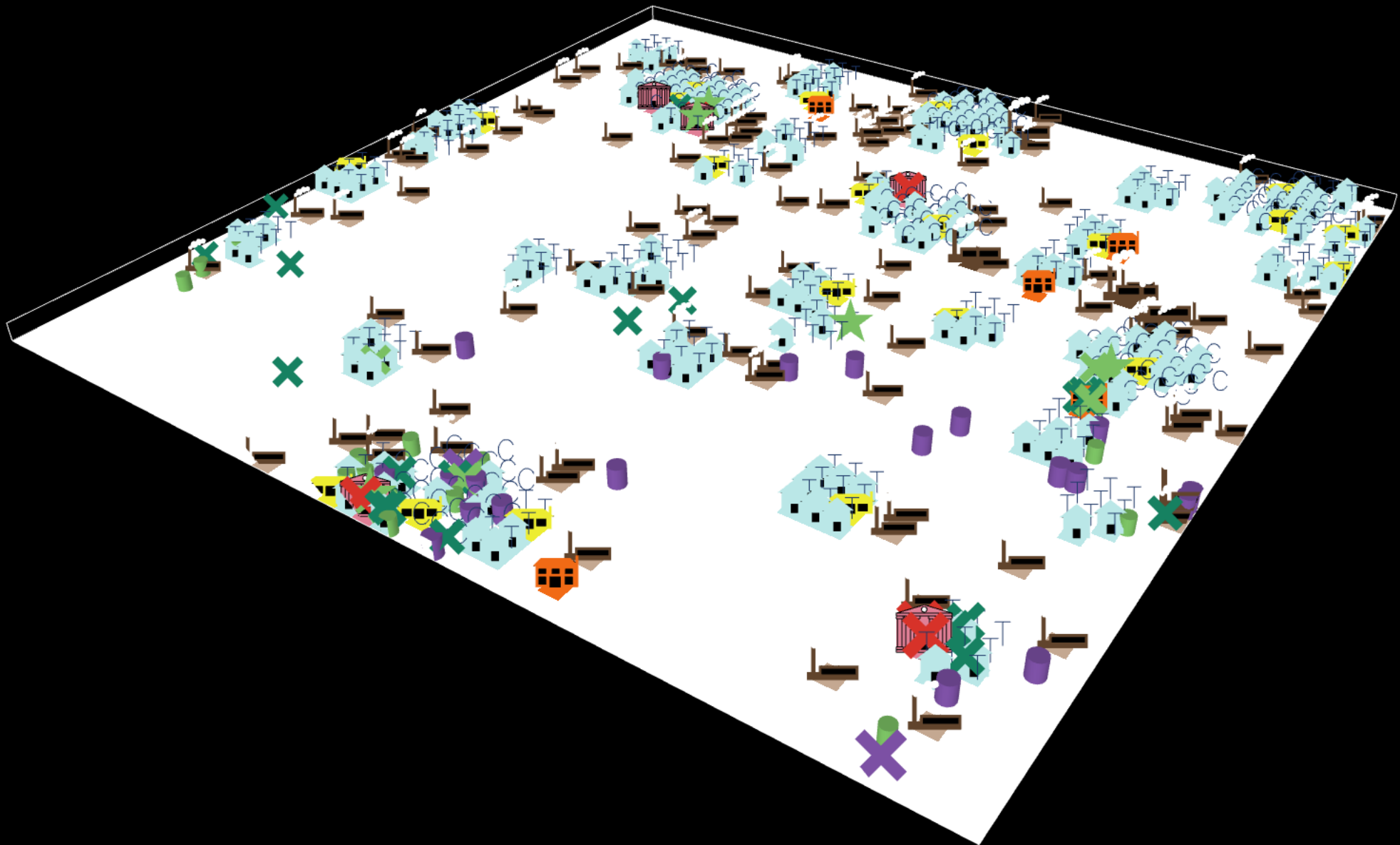
**Aympomatic teachers** 0

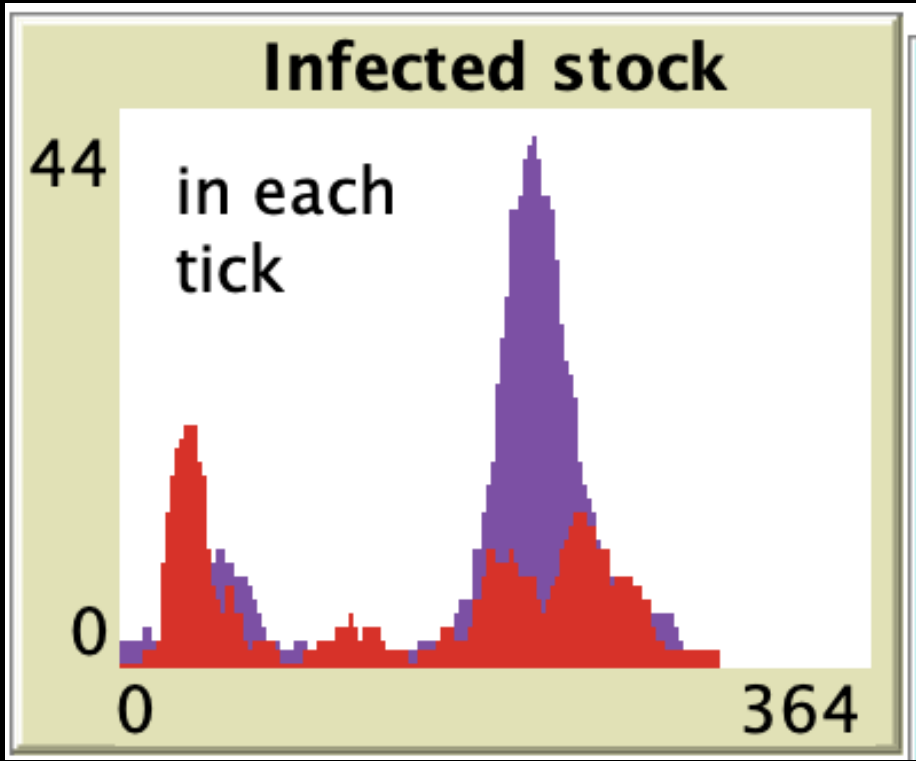
**teachs inf. sch.** 0

**studs inf. sch.** 0







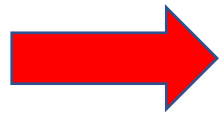


# Exploring analysis both as perspective views and as counterfactual ones

- We have houses, nursing homes, hospitals, factories (offices, shops), schools.
- We will explore:
  - as a perspective choice, school in September;
  - as a counterfactual analysis, school in May;
  - as a counterfactual analysis, preserving health of fragile workers.

# School in September (1/3): Off

	with NHs affected: no. events, mean no. symptomatic people, (duration)	with NHs not affected: no. events, mean no. symptomatic people, (duration)	contagions at school, sympt. and asympt. (mean values)		contagions out of school, sympt. and asympt. (mean values)	
			doc.	stu.	doc.	stu.
tests completed before August 18 <sup>th</sup> (excluding 8 cases completed in a few days)	33, 29.7, (102,5)	111, 9.2, (89,7)				
August 18 <sup>th</sup> : open cases, average no. symptomatic at the date	15, 166.7	33, 105.2				
October 18 <sup>th</sup> : open cases, average no. symptomatic at the date	<b>14, 217.4</b>	<b>27, 172.8</b>				
ratios 10.18/8.18	0.93, 1.30	0.82, 1.64				
at the end of the simulation (excluding the 8 cases completed in a few days)	48, 98.5	144, 50.0	0	0.01	0.58	1.26



# School in September (1/3): Off

**Realistic for Piedmont**  
(could contain a light overvaluation of the contagions in nursing homes)

	with NHs affected: no. events, mean no. symptomatic people, (duration)	with NHs not affected: no. events, mean no. symptomatic people, (duration)	contagions at school, sympt. and asympt. (mean values)		contagions out of school, sympt. and asympt. (mean values)	
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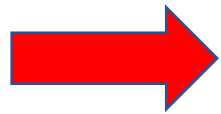
# School in September (2/3): **On**

	with NHs affected: no. events, mean no. symptomatic people, (duration)	with NHs not affected: no. events, mean no. symptomatic people, (duration)	contagions at school, sympt. and asympt. (mean values)		contagions out of school, sympt. and asympt. (mean values)	
			doc.	stu.	doc.	stu.
tests completed before August 18 <sup>th</sup> (excluding 7 cases completed in a few days)	41, 22.9, (99,0)	106, 6.9, (86.7)				
August 18 <sup>th</sup> : open cases, average no. symptomatic at the date	25, 129.6	21, 127.9				
October 18 <sup>th</sup> : open cases, average no. symptomatic at the date	<b>23, 194.7</b>	<b>20, 196.8</b>				
ratios 10.18/8.18	0.92, 1.50	0.95, 1.54				
at the end of the simulation (excluding the 7 cases completed in a few days)	66, 101.2	127, 43.5	0.12	0.18	0.64	1.12



# School in September (2/3): **On**

	with NHs affected: no. events, mean no. symptomatic people, (duration)	with NHs not affected: no. events, mean no. symptomatic people, (duration)	contagions at school, sympt. and asympt. (mean values)		contagions out of school, sympt. and asympt. (mean values)	
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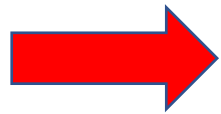
No Sep school

0.93, 1.30	0.82, 1.64
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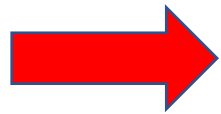
# School in September (3/3): **On, doubling classrooms**

	with NHs affected: no. events, mean no. symptomatic people, (duration)	with NHs not affected: no. events, mean no. symptomatic people, (duration)	contagions at school, sympt. and asympt. (mean values)		contagions out of school, sympt. and asympt. (mean values)	
			doc.	stu.	doc.	stu.
tests completed before August 18 <sup>th</sup> (excluding 16 cases completed in a few days)	44, 26.1, (101,2)	94, 8.3, (86,3)				
August 18 <sup>th</sup> : open cases, average no. symptomatic at the date	23, 130.1	23, 91.0				
October 18 <sup>th</sup> : open cases, average no. symptomatic at the date	<b>17, 191.2</b>	<b>16, 175.0</b>				
ratios 10.18/8.18	0.74, 1.47	0.70, 1.92				
at the end of the simulation (excluding the 16 cases completed in a few days)	67, 84.8	117, 39.7	0.03	0.08	0.39	1.03



# School in September (3/3): **On, doubling classrooms**

	with NHs affected: no. events, mean no. symptomatic people, (duration)	with NHs not affected: no. events, mean no. symptomatic people, (duration)	contagions at school, sympt. and asympt. (mean values)		contagions out of school, sympt. and asympt. (mean values)	
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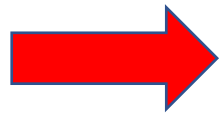


No Sep school

0.93, 1.30	0.82, 1.64
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ratios 10.18/8.18	0.74, 1.47	0.70, 1.92				
at the end of the simulation (excluding the 16 cases completed in a few days)	67, 84.8	117, 39.7	0.03	0.08	0.39	1.03



No Sep school

No doubling

0.93,  
1.30

0.82,  
1.64

0.92,  
1.50

0.95,  
1.54

# School in May: **On (Sep On)**

	with NHs affected: no. events, mean no. symptomatic people, (duration)	with NHs not affected: no. events, mean no. symptomatic people, (duration)	contagions at school, sympt. and asympt. (mean values)		contagions out of school, sympt. and asympt. (mean values)	
			doc.	stu.	doc.	stu.
tests completed before August 18 <sup>th</sup> (excluding 11 cases completed in a few days)	51, 31.5, (106,3)	96, 5.9, (85,5)				
August 18 <sup>th</sup> : open cases, average no. symptomatic at the date	13, 140.6	29, 127.2				
October 18 <sup>th</sup> : open cases, average no. symptomatic at the date	<b>12, 192.3</b>	<b>26, 180.8</b>				
ratios 10.18/8.18	0.92, 1.37	0.90, 1.42				
at the end of the simulation (excluding the 11 cases completed in a few days)	64, 71.9	125, 50.0	0.06	0.15	0.53	1.04



# School in May: **On (Sep On)**


	with NHs affected: no. events, mean no. symptomatic people, (duration)	with NHs not affected: no. events, mean no. symptomatic people, (duration)	contagions at school, sympt. and asympt. (mean values)		contagions out of school, sympt. and asympt. (mean values)	
			doc.	stu.	doc.	stu.
tests completed before August 18 <sup>th</sup> (excluding 11 cases completed in a few days)	51, 31.5, (106,3)	96, 5.9, (85,5)				
August 18 <sup>th</sup> : open cases, average no. symptomatic at the date	13, 140.6	29, 127.2				
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ratios 10.18/8.18	0.92, 1.37	0.90, 1.42				
at the end of the simulation (excluding the 11 cases completed in a few days)	64, 71.9	125, 50.0	0.06	0.15	0.53	1.04

Case no school

23, 194.7	20, 196.8
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# School in May: **On (Sep On)**

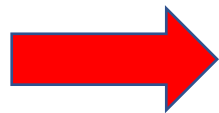
	with NHs affected: no. events, mean no. symptomatic people, (duration)	with NHs not affected: no. events, mean no. symptomatic people, (duration)	contagions at school, sympt. and asympt. (mean values)		contagions out of school, sympt. and asympt. (mean values)	
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ratios 10.18/8.18	0.92, 1.37	0.90, 1.42				
at the end of the simulation (excluding the 11 cases completed in a few days)	64, 71.9	125, 50.0	0.06	0.15	0.53	1.04

12 to 23 does  
not mean that  
the wisest  
solution  
would have  
been to open  
the school ...  
to reduce the  
epidemic



Case no school

23, 194.7	20, 196.8
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# Fragile workers **at home** (1/2)

	with NHs affected: no. events, mean no. symptomatic people, (duration)	with NHs not affected: no. events, mean no. symptomatic people, (duration)
tests completed before August 18 <sup>th</sup> (excluding 9 cases completed in a few days)		155, 8.8, (97,0)
August 18 <sup>th</sup> : open cases, average no. symptomatic at the date		36, 93.9
October 18 <sup>th</sup> : open cases, average no. symptomatic at the date		30, 143.8
at the end of the simulation (excluding the 9 cases completed in a few days)		191, 36.9

# Fragile workers **in working places** (2/2)

	with NHs affected: no. events, mean no. symptomatic people, (duration)	with NHs not affected: no. events, mean no. symptomatic people, (duration)
tests completed before August 18 <sup>th</sup> (excluding 5 cases completed in a few days)	5, 23.0, 104,8)	127, 12.4, (91.6)
August 18 <sup>th</sup> : open cases, average no. symptomatic at the date	2, 123.0	61, 124.0
October 18 <sup>th</sup> : open cases, average no. symptomatic at the date	2, 182.0	47, 181.7
at the end of the simulation (excluding the 5 cases completed in a few days)	7, 87.6	188, 68.0

127 concluded against 155

61 open against 36

47 open against 30

191, **36.9**



More in an [article disseminating the results of the model](#)  
(in Italian)

# Final technical notes

It is possible to run this model both online at <https://terna.to.it/simul/SIsaR.html>, or to download it from the same address and use it locally, installing [NetLogo](#), free and open-source shell for agent-based models.

# Thanks

Pietro Terna

[pietro.terna@unito.it](mailto:pietro.terna@unito.it) <https://terna.to.it>

Slides and project at <https://terna.to.it/simul/SIsaR.html>

YouTube channel:

<https://www.youtube.com/channel/UC31OBWUtgee7BQ7qQ3bqNeA>