How Not to Become a Global Pandemic Statistic

New Mexico Supercomputing Challenge

Final Report

April 7, 2010

Team #15
Aspen Elementary

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Zeynep Unal

Team Mentors
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Executive Summary

Our project for the New Mexico Supercomputing Challenge was to learn about H1N1 and understand how it spreads. We had the school take surveys and tallied the results so we could use them in our model.

In our model, we set it up to look like out school and showed how the H1N1 virus spreads. We created two populations of agents, one that had bad behaviors and the other with good behaviors. The survey results helped us initialize the behaviors. The populations were split evenly through out grades K-6 and were able to move between classrooms and playgrounds where they could interact and possibly transmit the virus. We modeled the evolution of the illness when the agents collided in the simulation. The stages each agent could go through was healthy to exposed, then possibly becoming sick or becoming healthy again, and if they were exposed and became sick, they would either recover from the illness or die. If the agent recovers from the illness, they become immune and cannot become sick again, however they can become exposed and transfer the virus within the population. We tracked the number of agents in each state as the model ran, and plotted the results as a function of time.

We found that if you have good behaviors your chance of getting sick is less than if you have bad behaviors. If you have good behaviors and you are in a large group of people with bad behaviors, you are more likely to become infected because you have a higher probability of interacting with someone that is sick.

Scope of Project

In supercomputing we are studying the H1N1 influenza virus and how it spreads. Also, we are modeling the spread of the disease in Starlogo TNG, a computer program that implements agent-based modeling.

The H1N1 virus spreads from person to person, with different behaviors and habits affecting the chances of how people become infected. There are different behaviors that can affect the spreading of the disease, such as the frequency of washing of hands, coughing and sneezing into your elbow or coughing unprotectedly, and whether or not people share food. H1N1 is also referred to as swine-flu, and its symptoms are coughing, muscle pains, weaknesses, chills, fever, sore throat, and headache. In other words, you feel pretty bad if you get it.

Reason for choosing this topic

Our curiosity to understand the spreading of the H1N1 virus arose when many people started catching influenza, and becoming sick, at the Los Alamos Middle School in 2009. The virus spread rapidly through the schools and the community of Los Alamos. We were worried that the infections might spread widely into the Aspen Elementary school, which we attend. Some of us were also worried because the virus can be deadly, causing death for young people in rare cases. When one comes across a situation that is frightening or surprising, then we felt it is a good idea to learn as much as you can about it. In this case, by understanding the disease and how it spreads, we might be able to recommend behaviors that might prevent or lower the chances of getting the illness.

Our approach

Our team went to Santa Fe to take a class on how to use Starlogo TNG, and to hear the logic behind this computer modeling program. We also had a visitor from the Los Alamos National Laboratory, Sara Del Valle, who talked about related modeling approaches used in the lab. These methods are referred to as agent based modeling, and can be used for simulating many phenomena including the spreading of disease, understanding traffic flow, electrical grids, etc.

We conducted a survey to help obtain some information we needed for our Starlogo TNG modeling. We created a set of questions for everyone at Aspen Elementary school – both students and teachers. We tallied the results, to be shown in the following pages.

Survey

We had everyone at Aspen School take a survey for us. We felt this necessary so we could base our model off of the results that were shown. We learned a great deal about tallying results, and the computer program Numbers. While going through all the results we found some very interesting answers. For instance one of our questions was “ How many hours of sleep do you get?” so some people answered “I get 15 hours of sleep.” You would have to go to bed at 4:00 in the afternoon and wake up at 7:00 in the morning! So we asked our selves is that really realistic? We decided that we would not include the unrealistic answers in our model. The results are shown in Figure 1.

After we tallied up the results we graphed them in the computer program Numbers. We had two ways of graphing them: grades separated, and all grades put together.

Shown below are two examples of our graphs. We have color coded them by the answers that we show.

We chose the graphs to be shown here because, we thought that these where two of the best graphs to show you the variety of answers that we found while tallying the results.

As you can see on Figure 2 “Do you wash your hands before meals?”, most people said “usually”, some people said “yes”, and a few people said “no”.

We predicted that the kindergartners are fairly good about washing their hands because, the teachers say “Everybody go wash your hands.” so we figured they were probably the best kids in the school. Also, we figured that they most likely wont lie.

We liked the outcome of our results. But if we could go back and do the survey a little differently, we probably would have asked the teachers to put their names on their classes surveys, because we spent many recesses running around the school making sure that we had all the teachers surveys. But over all we think the general outcome was good.

The survey questionnaire and all tabulated results are located in Appendix A.

Figure 1A

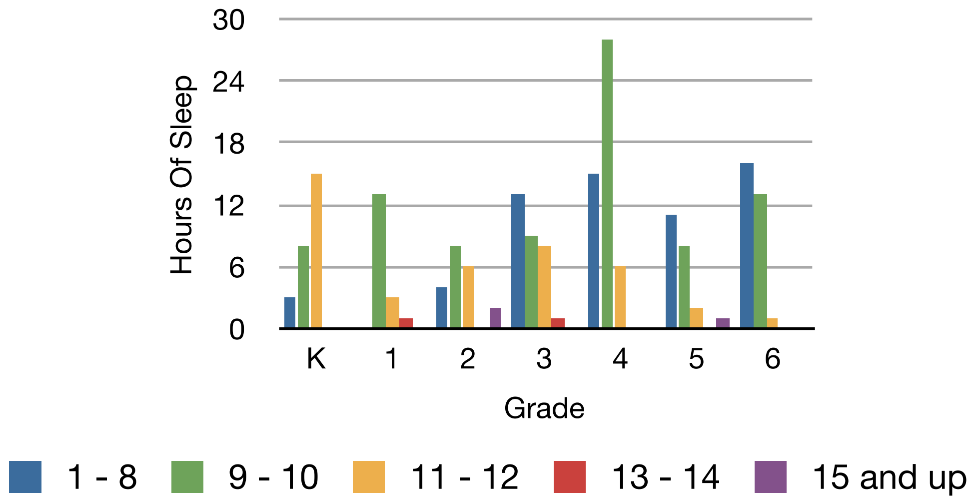


Figure 1B

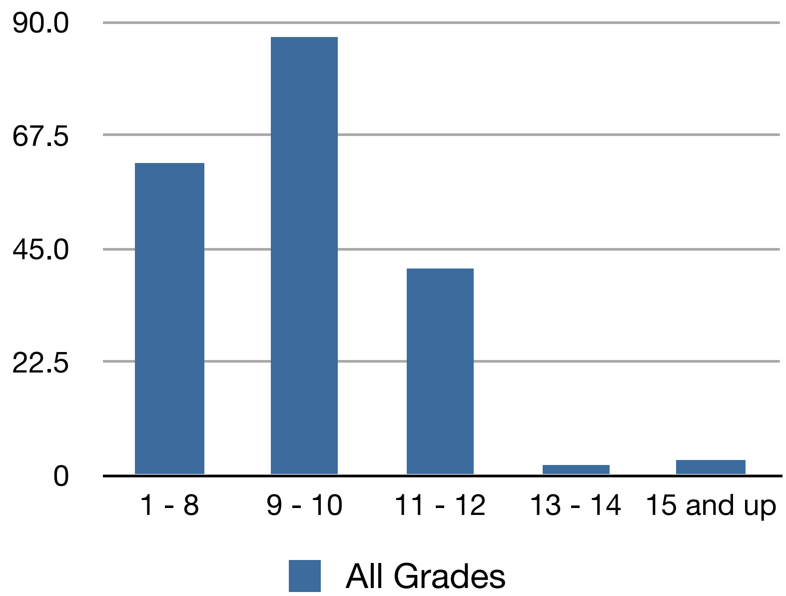


Figure 2A

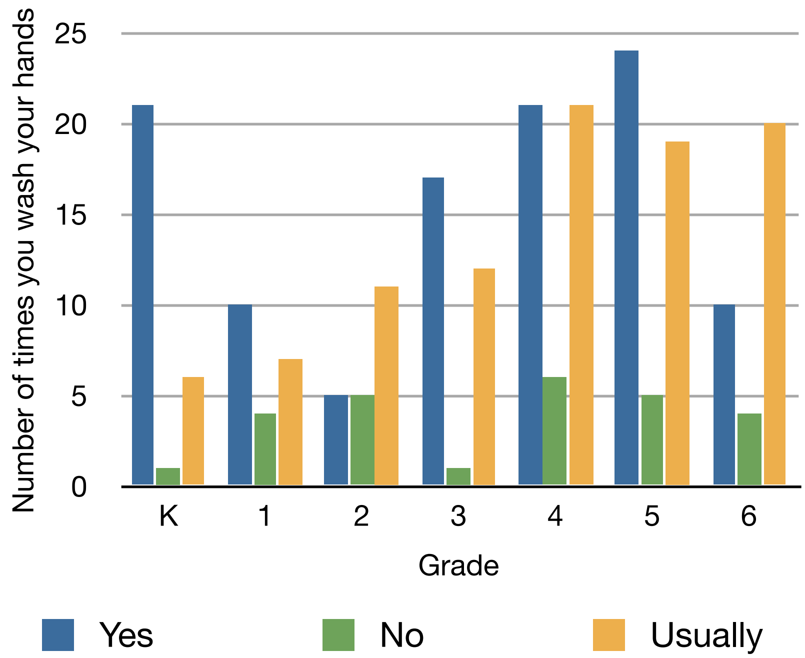
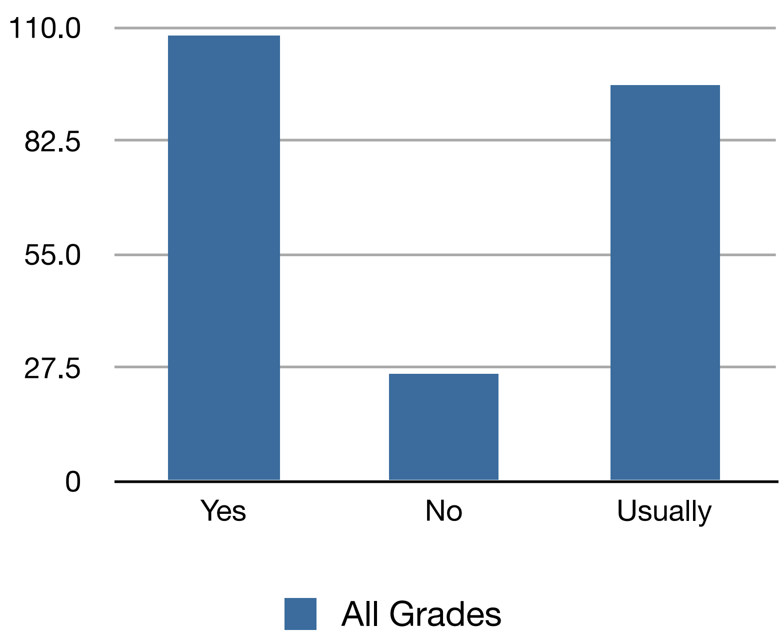


Figure 2B



Mobility Modeling

The model has two populations. The populations move around according to their grade (Kindergarten through Sixth grade). Each agent has a variable that tells what grade it is in. In the model the agents are either in their Classrooms or at the Playground.

The two populations have good and bad agents. Each of the populations moves the same as the other. Each population is treated the same way. They are moved the same way in separate pieces of computer code. Each code contains “good” and “bad” agents-so no class has just good agents or just bad agents.

In the model we created areas. We have seven Classrooms and the Playground. We used walls to create these areas so when an agent runs into a wall it will turn 180 degrees around and will then continue moving within that area. On the Spaceland all of the agents start in the Playground. After a selected amount of time the agents move to their Classrooms. We used a slider that sets a variable length of time in the Classrooms or on the Playground. There are seven Classrooms – one for each grade level. Each agent goes to his or her grade level class. After the class time the agents move back to the Playground.

We have set our model up so the agents go to random locations. At a time the agents instantaneously move to the Playground or the Classrooms. They are placed randomly within that area. We do this so the agents do not go on top of each other. The agents then start moving and interacting with each other.

In our model we used a clock. The clock would run without stopping. We would use the clock time for creating plots. We would use the clock time and the total amount of time on the Playground and in the Classroom in the remainder function to determine if the agents are in their Classrooms or on the Playground.

The Spreading of Influenza

The model has 2 populations. One population for agents that use good behaviors and one population for agents that use bad behaviors. In the model each population is it’s own breed. In the spaceland we used business men to represent agents the use good behaviors and Homer Simpson to represent agents that use bad behaviors. Each population is split evenly into 7 grades, kindergarten through sixth grade. Each agent has a variable that tells what grade it is in.

The number of agents in each population can be adjusted by sliders. In our model we used a total of 160 agents. This is about one-half of the number of students in Aspen because the model only had one classroom per grade and Aspen has about two classrooms per grade. So the number of students in each classroom in the model is about the same as the at Aspen.

Each agent could be in one of five different states. They are: Healthy, Exposed, Sick, Immune and Dead. Each state has the following characteristics:

Healthy - The agent is healthy.

Exposed - The agent has been exposed to the illness.

Sick - The agent is sick.

Immune - The agent is healthy and cannot get sick again.

Dead - The agent is dead.

The model starts with about ten percent of the agents being sick and the rest healthy. We did not adjust this value in our simulations. When the simulation is running the agents can transfer the illness only by colliding with other agents.

When a sick agent collides with a healthy agent, the healthy agent becomes exposed. Then in the next time step the exposed agent either becomes sick or goes back to being healthy. The probability that the agent becomes sick or healthy can be adjusted by a slider.

During each time step sick agents can either stay sick, turn immune, or die. The probability of each of these can be adjusted. This process is illustrated in Figure 3.

We stop the simulation when there are no more sick agents, because nothing there is no more illness in the populations to be transferred.

The probabilities for the simulation are adjusted by sliders. The difference between the good population and the bad population is that for the good population the chance that an exposed agent becomes sick is only 25%, while for the bad population then chance that an exposed agent becomes sick is 75%. This is a important setting for our model.

The other probabilities are the same for both the good and bad agents. The chance that a sick agent recovers and becomes an immune agent in one time step is 1%. This can be adjusted. The chance that a sick agent dies in one time step is 0.2%.

We decided to run the one simulation with three-quarters of the total number of agents (120) as good agents and one-quarter (40) as bad agents. We also ran the opposite case with 40 good agents and 120 bad agents. We will compare the results in the results section.

During the simulation we kept track of the number of healthy, sick, immune and dead agents for each population (good and bad) and each grade by using graphs.

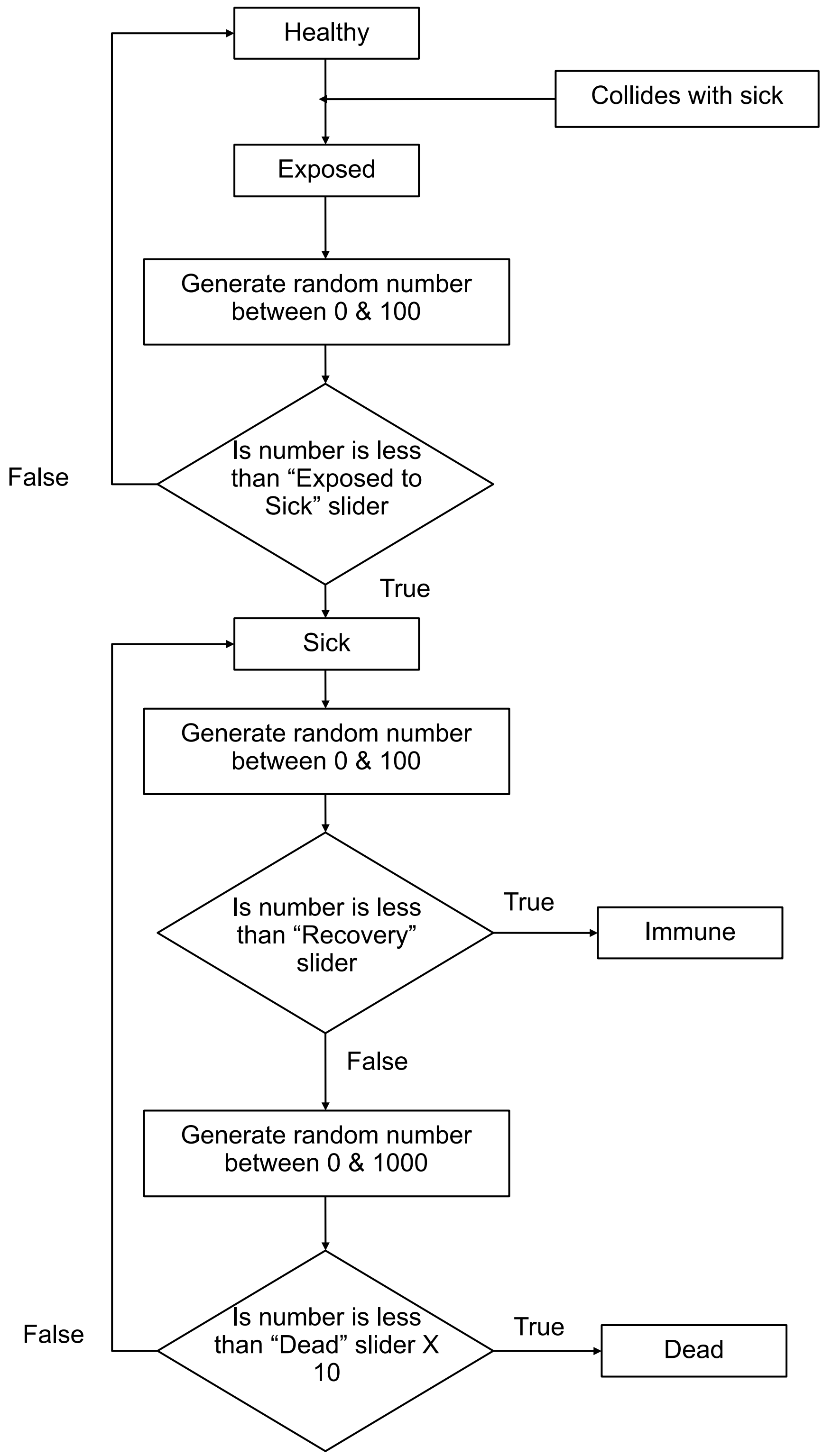


Figure 3: A flow diagram of disease progression.

Discussion of Results

We decided to run the model for two different cases. For the first case our populations had 120 agents that expressed good behaviors, “good agents”, and 40 agents that expressed bad behaviors, “bad agents”. For the second case we switched the number of agents and had 40 good agents and 120 bad agents. We kept the other values for the sliders the same for both cases. The values that we used are:

Good Agents - Exposed to Sick	25%
Bad Agents - Exposed to Sick	75%
Recorvery	1%
Death	0.20%
Recess Time	10
Class Time	40

We tracked the number of heathy, sick, dead and immune agents for the good population and the bad population for the whole school and also for each grade. We did not graph the number of exposed agents because an agent was exposed for only one time-step before changing to either healthy or sick.

Figure 4 shows the change with time of each of the states for the good agents. Figure 5 shows the change with time for the bad agents for case 1: 120 good agents and 40 bad agents.

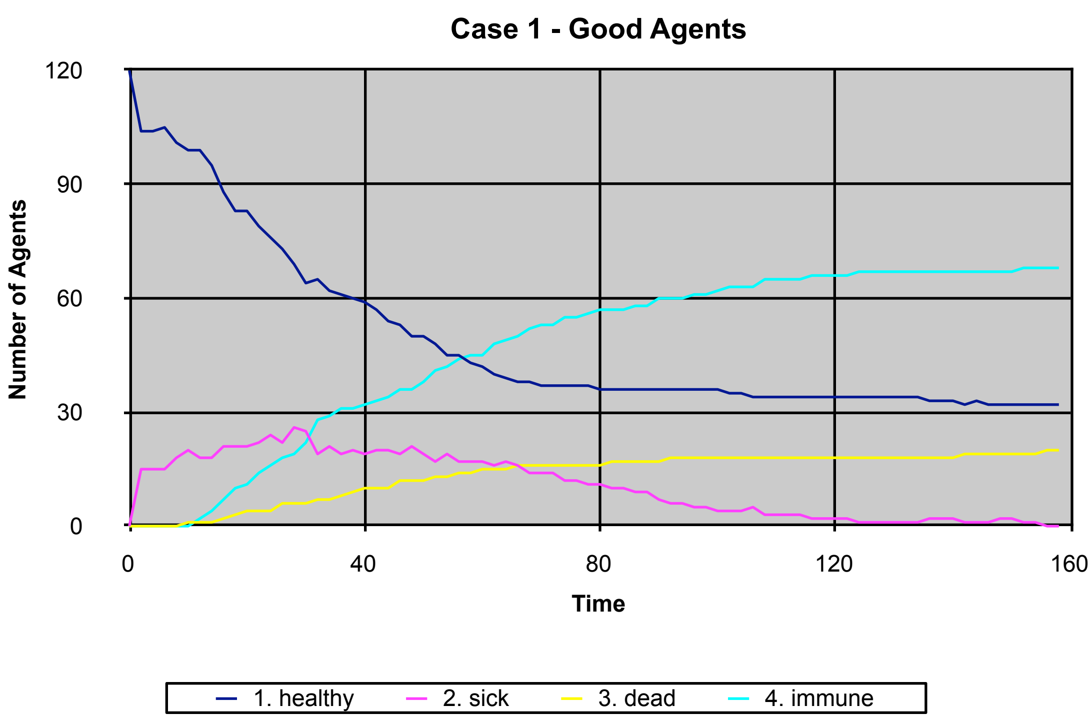


Figure 4. The time history of the number of good agents that are healthy, sick, dead and immune for case 1.

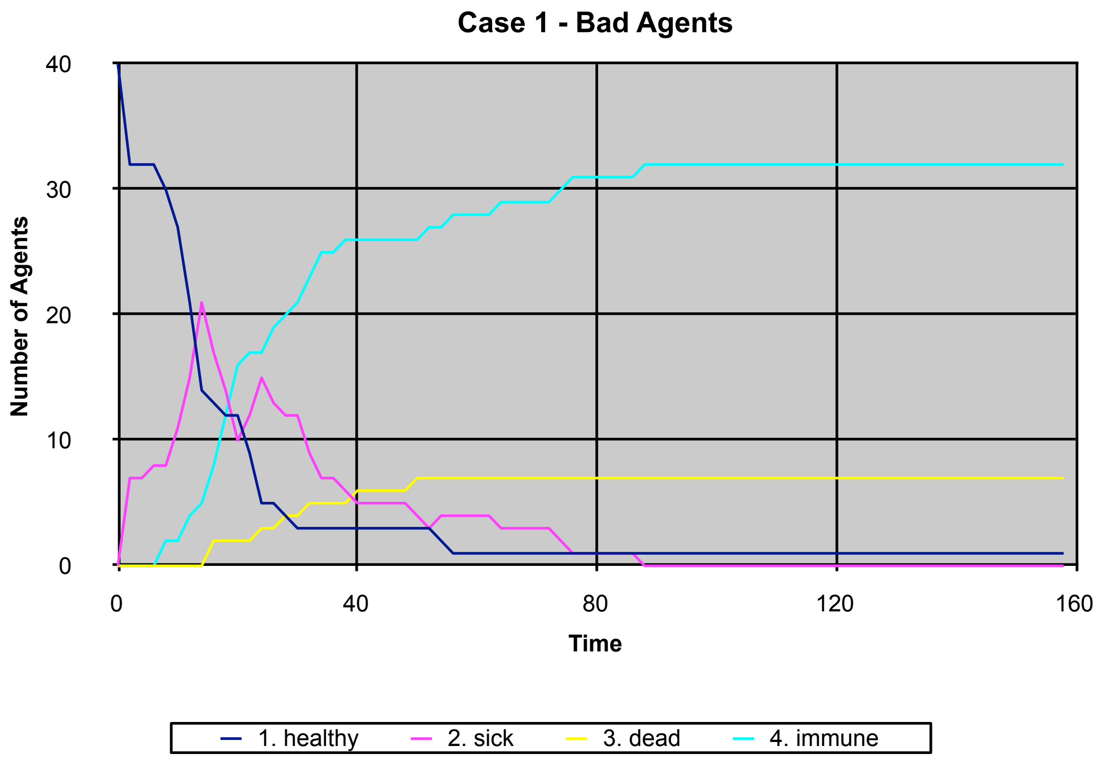


Figure 5. The time history of the number of bad agents that are healthy, sick, dead and immune for case 1.

For this case, at the end of the run about 1/4 of the good agents stayed healthy and only 1 of the bad agents stayed healthy. The total number of agents that did not get sick was 33. About 17% of the good agents and 17% of the bad agents died by the end of the run. About 56% of the good agents and 80% of the bad agents got sick and then recovered becoming immune.

Figure 5 shows the change with time of each of the states for the good agents. Figure A shows the change with time for the bad agents for case 1: 40 good agents and 120 bad agents.

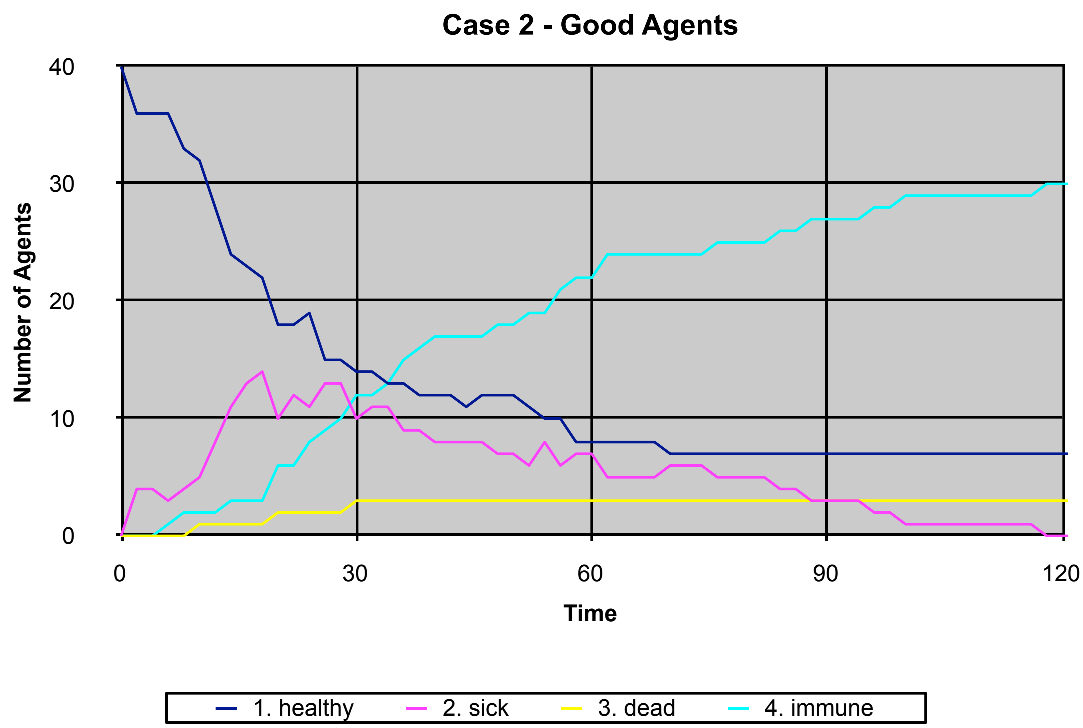


Figure 6. The time history of the number of good agents that are healthy, sick, dead and immune for case 2.

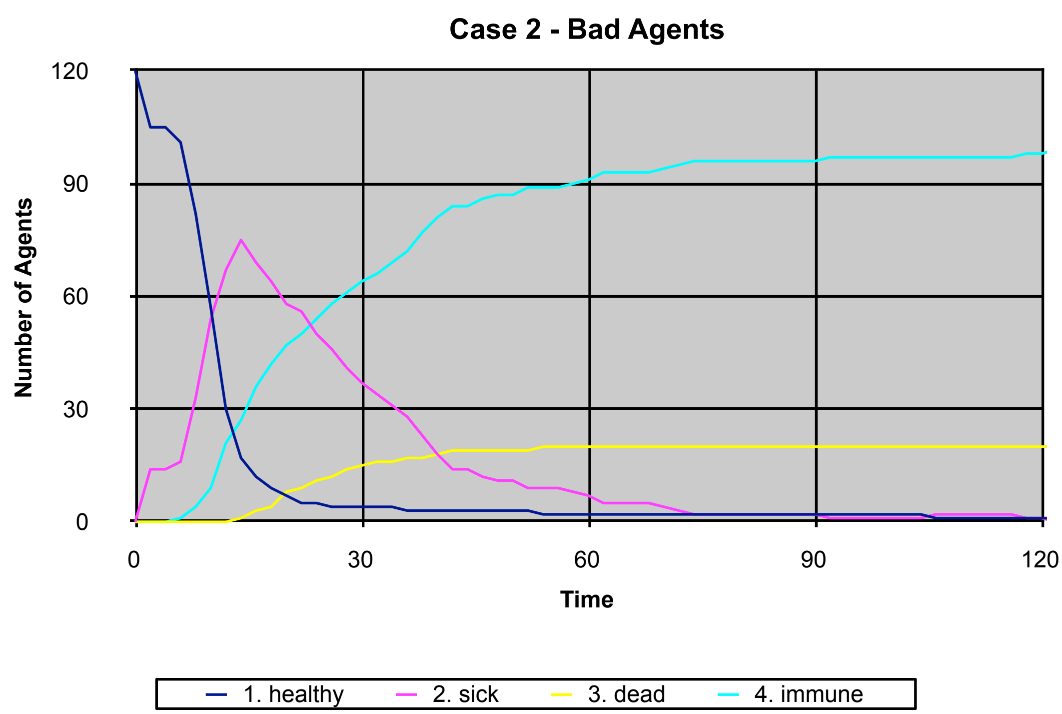


Figure 7. The time history of the number of bad agents that are healthy, sick, dead and immune for case 2.

For case 2, shown in Fugures 6 and 7, at the end of the run about 18% of the good agents stayed healthy and only 1 of the bad agents (1%) stayed healthy. The total number of agents that did not get sick was 8. About 8% of the good agents and 16% of the bad agents died by the end of the run. About 75% of the good agents and 83% of the bad agents got sick and then recovered becoming immune.

Conclusions

In our model, agents with good behaviors had a higher chance of staying healthy than agents with bad behaviors. This is what we expected. We also found that in populations with a larger number of good agents than bad agents fewer overall people got sick. In general, we expected more people to stay healthy.

Recommendations For Future Work

We could change a lot of things in our model or survey. But we recommend that you try these, if you have time. We could change the number of houses/classrooms we have. In our model we have one classroom per grade, we could change the number of classrooms to two or three per grade if we wanted to make our model more like Aspen school.

We could also change the location of the classrooms. For instance at Aspen all the grades are in the same building except for some kindergarten class and the sixth grade classes are outside in portables. Or we could change the number of people we have running around. Right now we have 160 people, but we could change that to around 300 people in our model. But of course we would have to change the number of classrooms there are.

We could change the length of time the agents interact with each other. When we are in school we have a morning recess of 15 minutes, lunch of 45 minutes, and afternoon recess of 15 minutes, and there are eight hours in a school day. We spend 1 hour and 15 minutes on the playground, and 6 hours and 45 minutes in our classrooms. So we could have the clock set at 15 time shares/minutes per recess, and the clock set at 45 time shares in the classrooms. We can change the amount of time the agents interact with each other on the playground or in the classrooms. Instead of adding more classrooms, we could change the size of the classrooms. So we'll take sixth grade as an example, there are two classrooms at Aspen. Instead of two classroom you cloud have one big one. But in our model we have one classroom, if we added more people to the model we could either expand the classroom or you could add another classroom.

We could also model with some percentage of the population having been immunized by having a flu shot. This would make those agents much less likely to go from exposed to sick. But as the immunization wears off, their probability of getting sick could increase.

Appreciation

We would like to thank the following people for helping us and giving us support: Sara Del Valle, Aspen students and staff, David DeCroix (mentor), David Oro (mentor), Mrs. Zeynep Unal, our parents, and the staff at the Santa Fe Complex.

Appendix A

Please Do Not Put Your Name!
We hope you fill out this survey truthfully!

Grade:___________

Are you a teacher or a student?
Circle One
Teacher Student

Are you a boy or girl?
Circle One
Boy Girl

Do you wash your hands before meals?
Circle One
Yes No Usually

How many times a day do you wash your hands?
Make your best guess
____

Do you have asthma or any other respiratory condition?
Circle One
Yes No I Don't Know

How many hours of sleep do you normally get?
Make your best guess

____

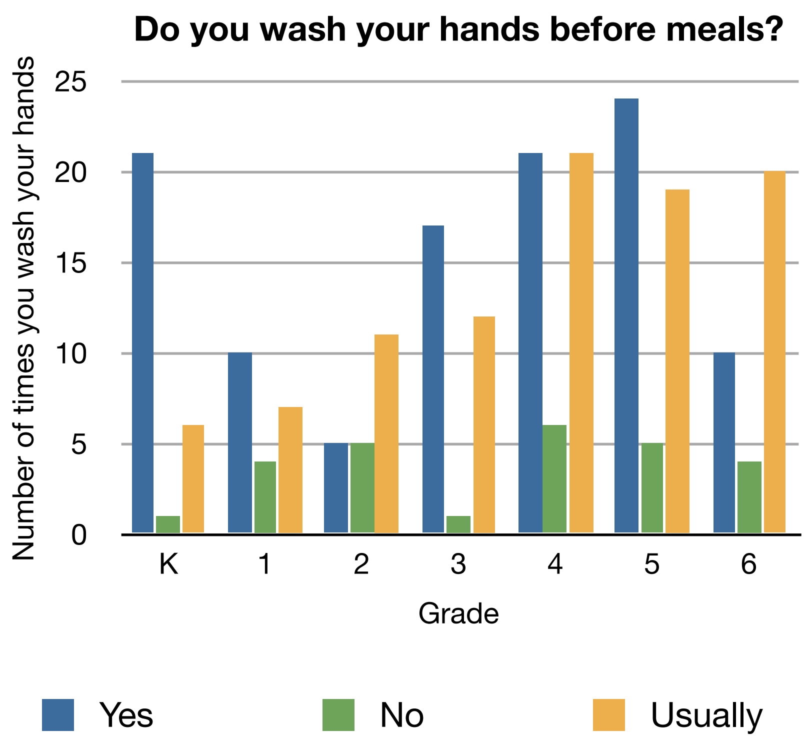
What kinds of snacks do you have?
Please write down two snacks that you normally have
1.____
2.____

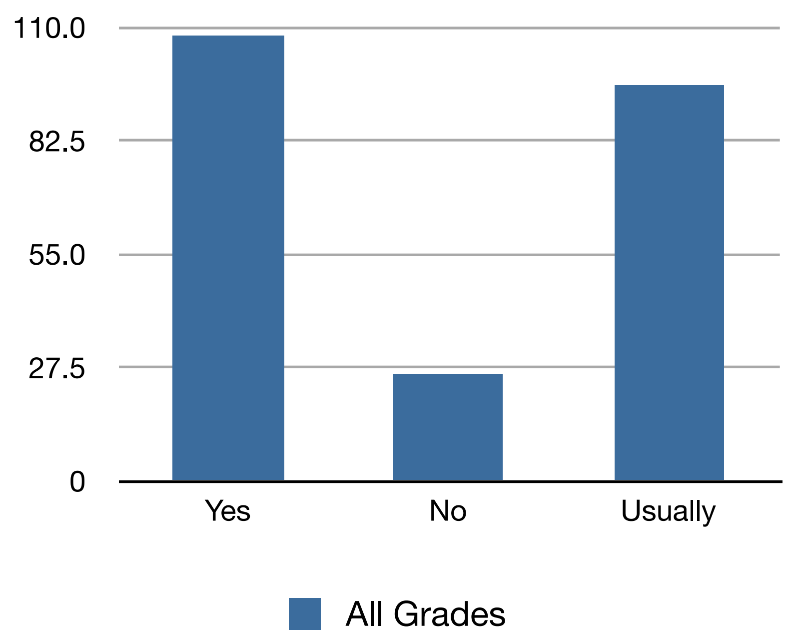
Do you share snacks?
Circle One
Yes No

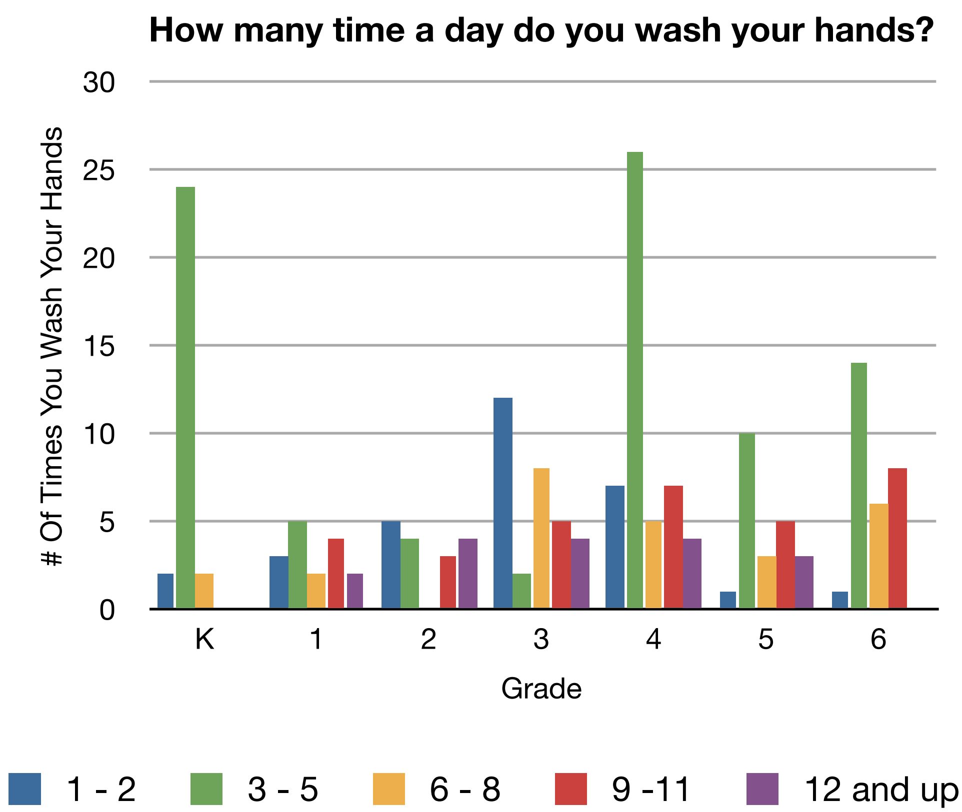
Did you get your flu shot?
Circle One
Seasonal H1N1 I Got Both I Didn't Get One

Do you cough into your elbow?
Circle One
Yes No

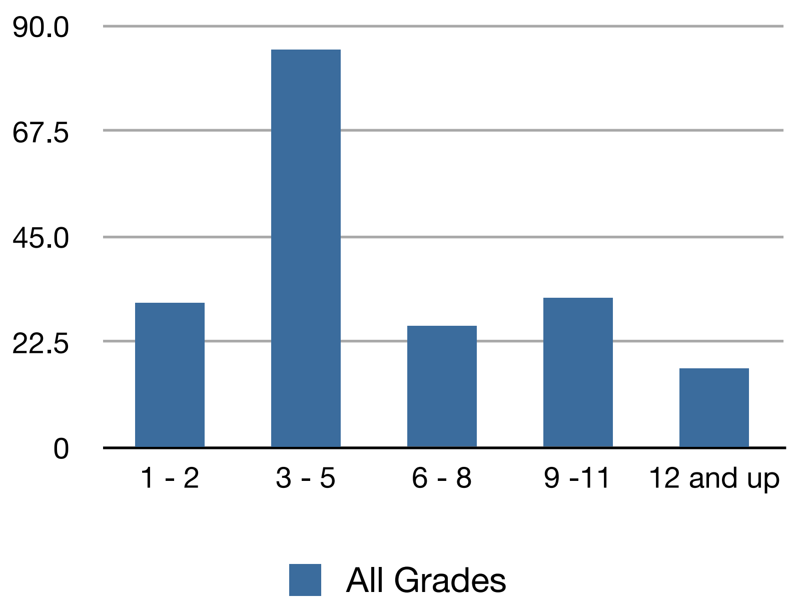
Appendix B


Do you wash your hands before meals?
Number of times you wash your hands
25
20
15
10
5
0
K
1
2
3
4
5
6
Grade
Yes
No
Usually

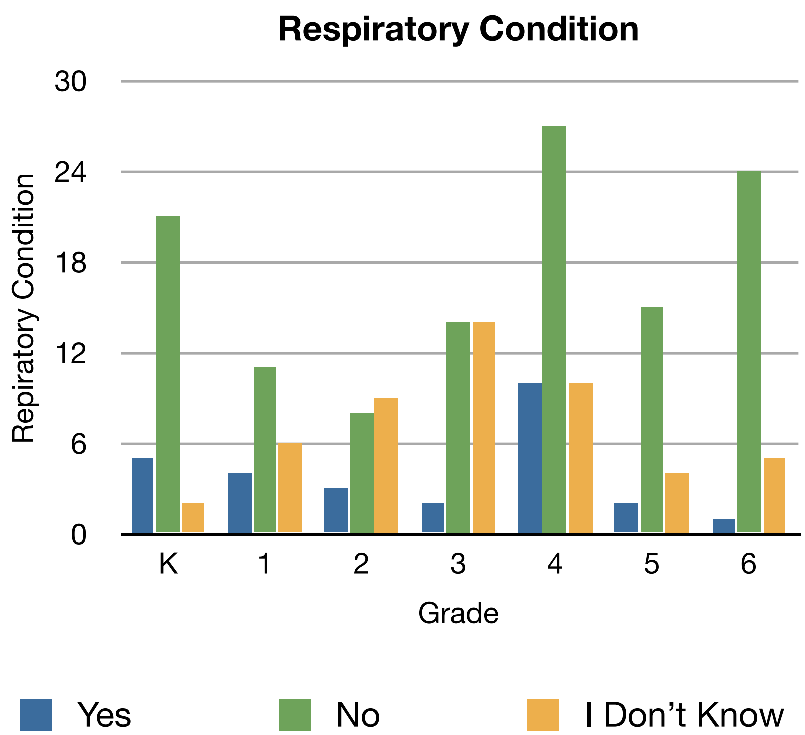

110.0
82.5
55.0
27.5
0
Yes
No
Usually
All Grades

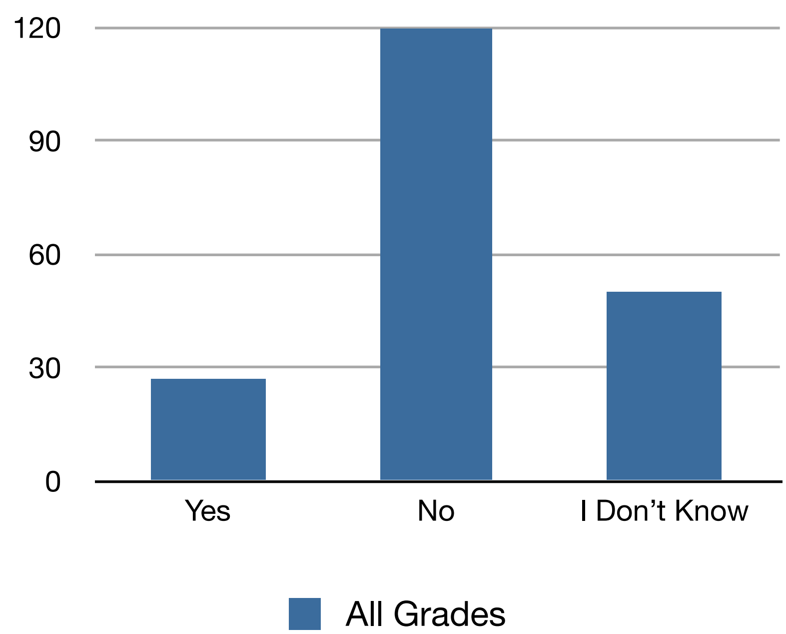


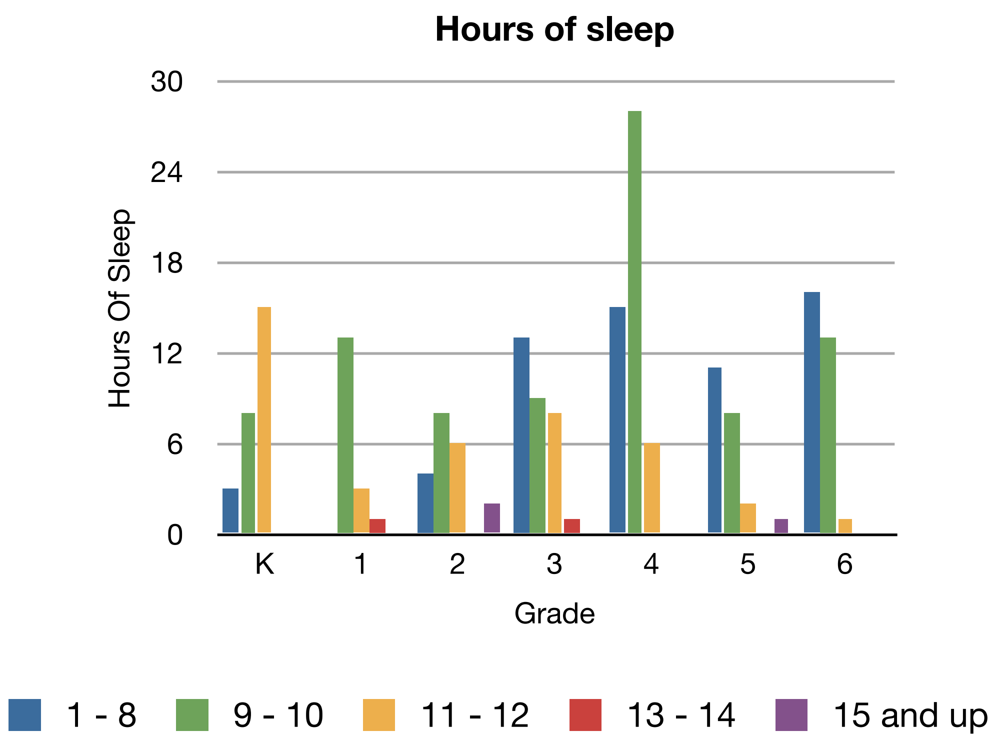
How many time a day do you wash your hands?
Of Times You Wash Your Hands
30
25
20
15
10
5
0
K
1
2
3
4
5
6
Grade
1 - 2
3 - 5
6 - 8
9 -11
12 and up

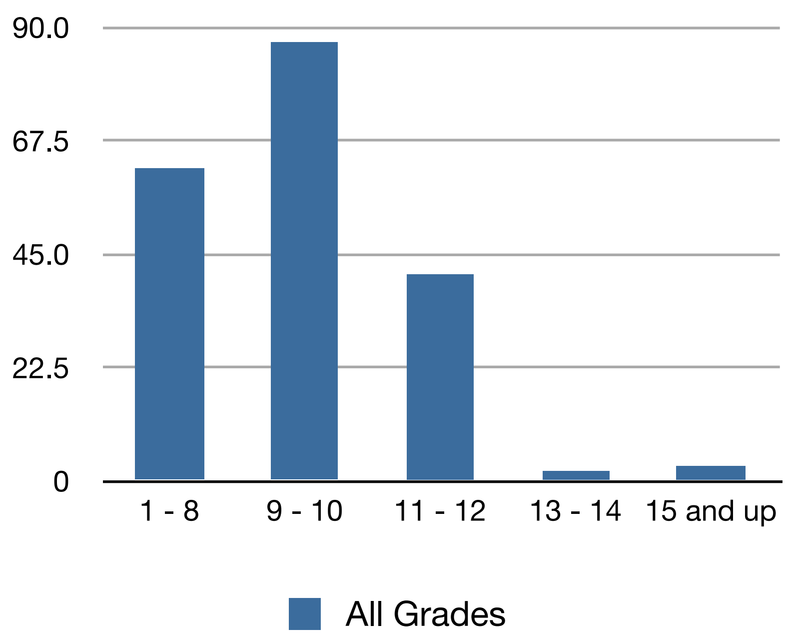


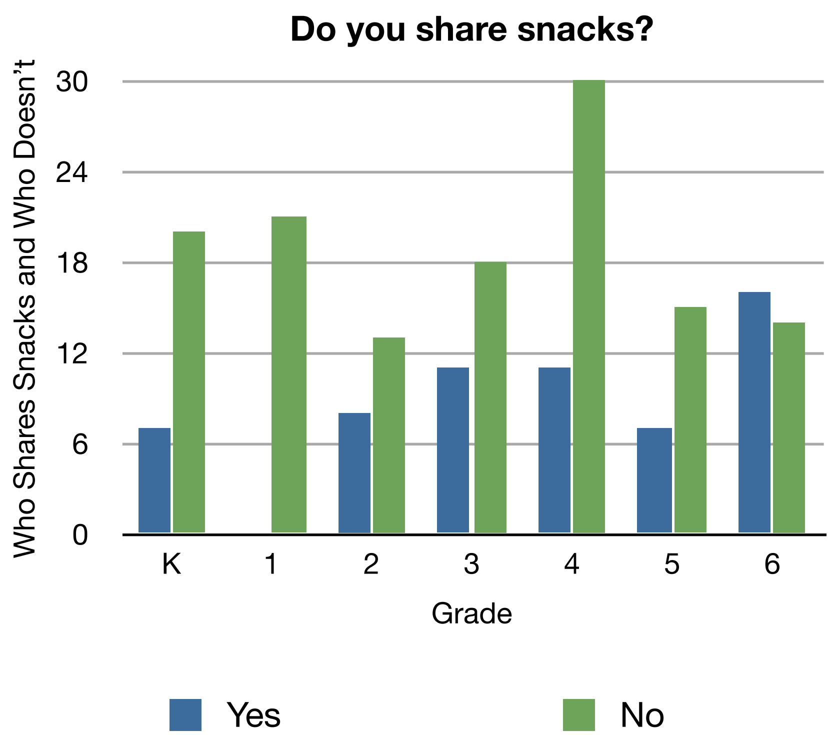
90.0
67.5
45.0
22.5
0
1 - 2
3 - 5
6 - 8
9 -11
12 and up
All Grades

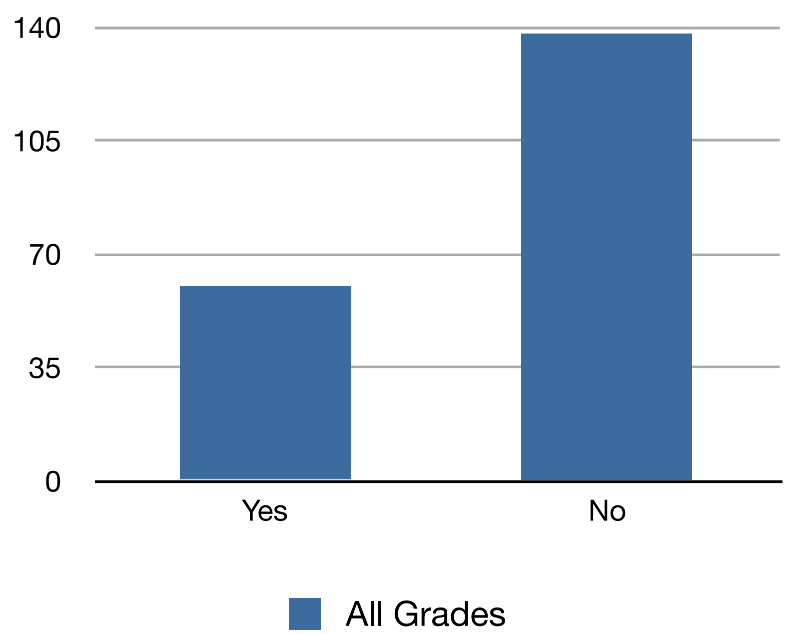

Respiratory Condition
Repiratory Condition
30
24
18
12
6
0
K
1
2
3
4
5
6
Grade
Yes
No
I Don't Know

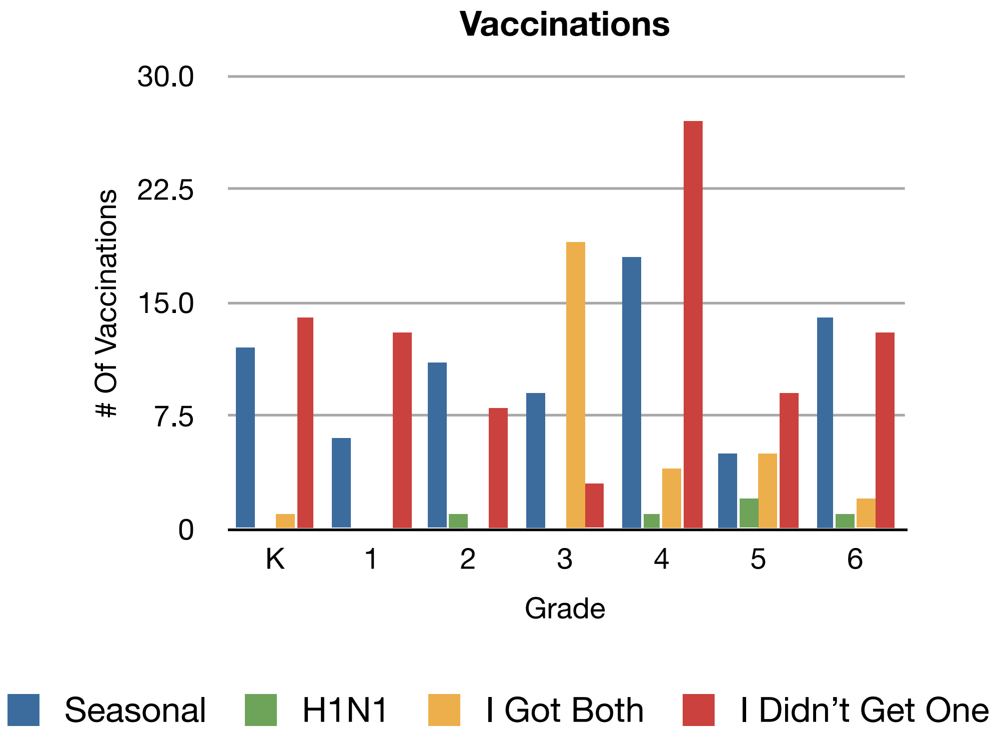

120
90
60
30
0
Yes
No
I Don't Know
All Grades

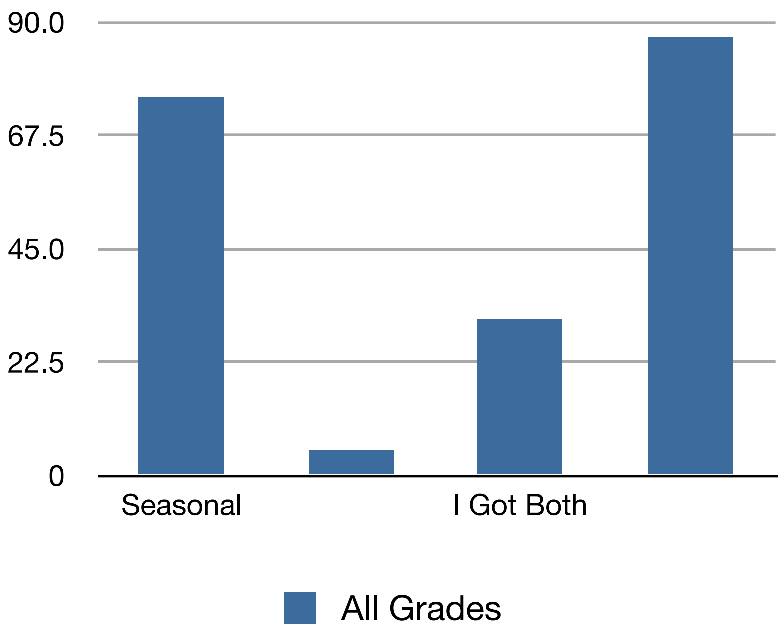

Hours of sleep
30
24
18
12
6
0
Hours Of Sleep
K
1
2
3
4
5
6
Grade
1 - 8
9 - 10
11 - 12
13 - 14
15 and up

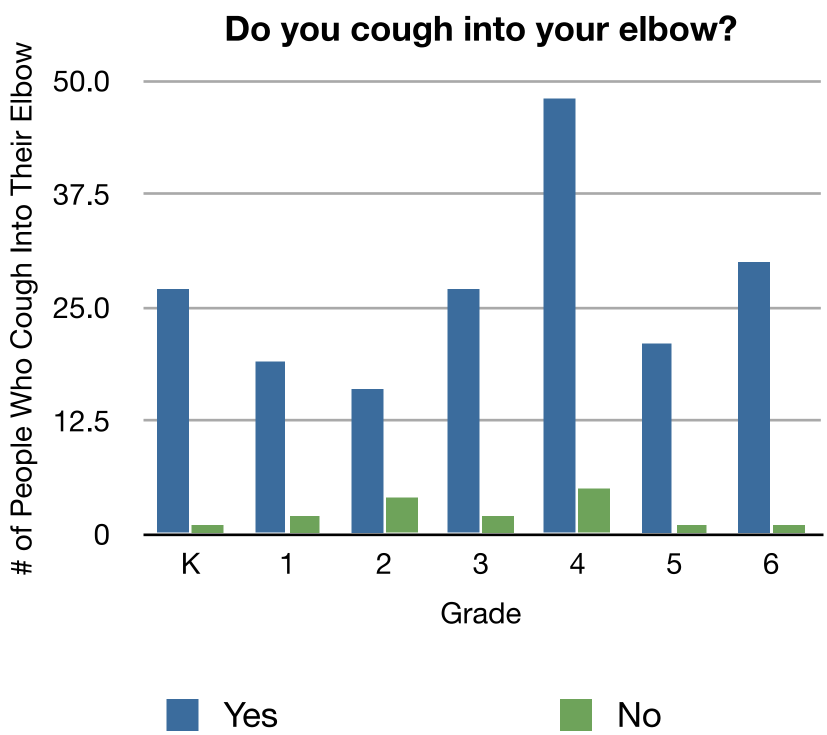

90.0
67.5
45.0
22.5
0
1 - 8
9 - 10
11 - 12
13 - 14
15 and up
All Grades

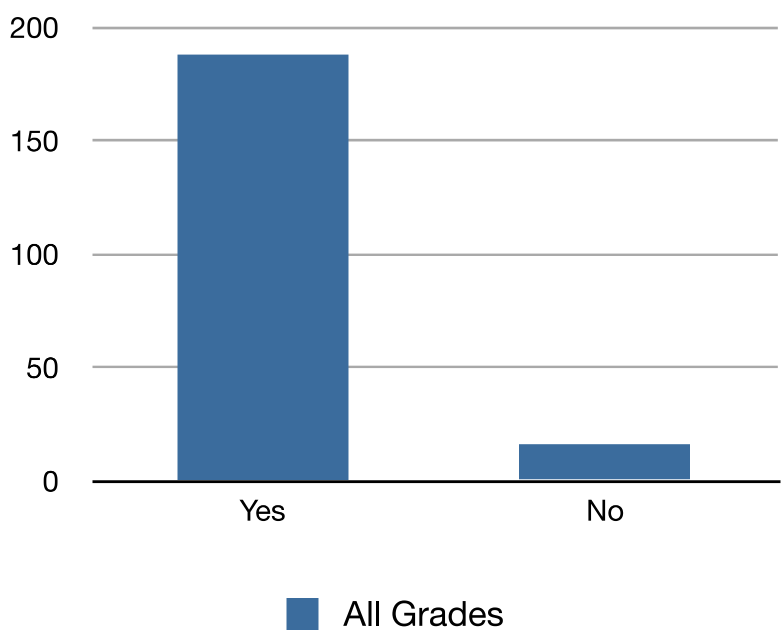

Do you share snacks?
Who Shares Snacks and Who Doesn't
30
24
18
12
6
0
K
1
2
3
4
5
6
Grade
Yes
No

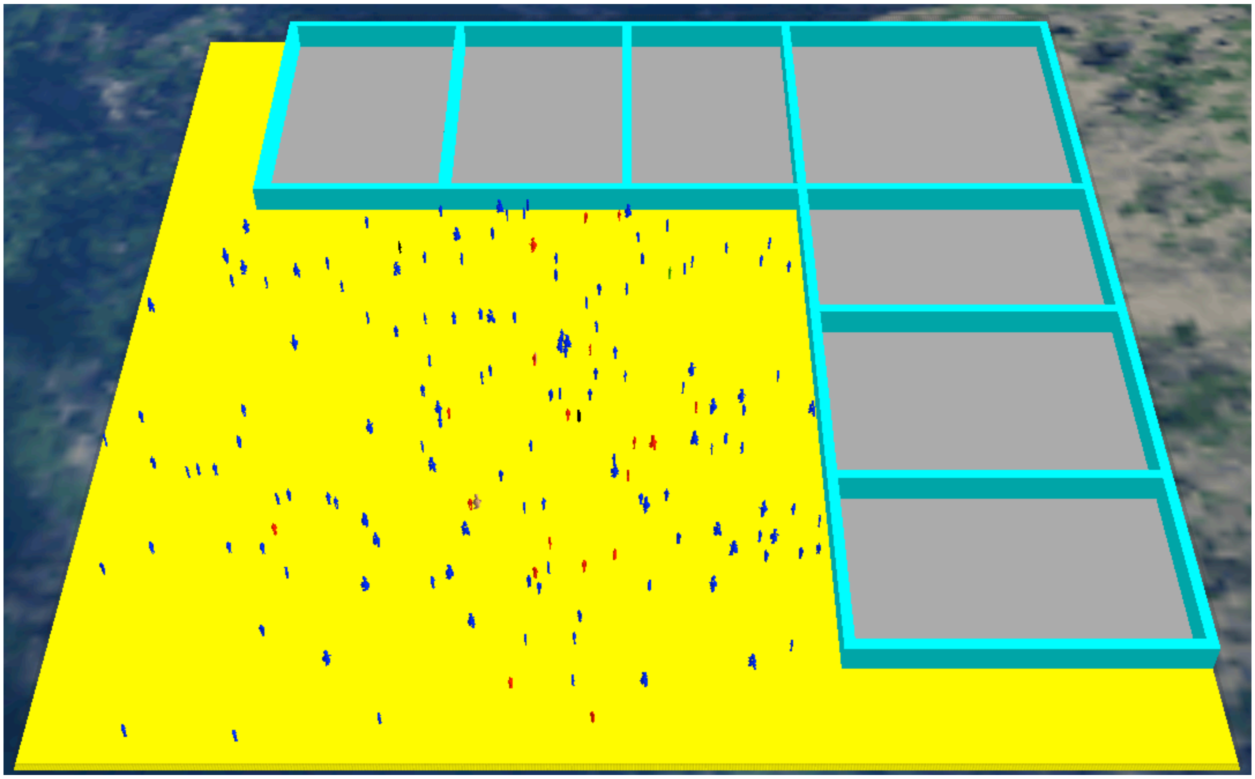

140
105
70
35
0
Yes
No
All Grades


Vaccinations
30.0
22.5
15.0
7.5
0
Of Vaccinations
K
1
2
3
4
5
6
Grade
Seasonal
H1N1
I Got Both
I Didn’t Get One

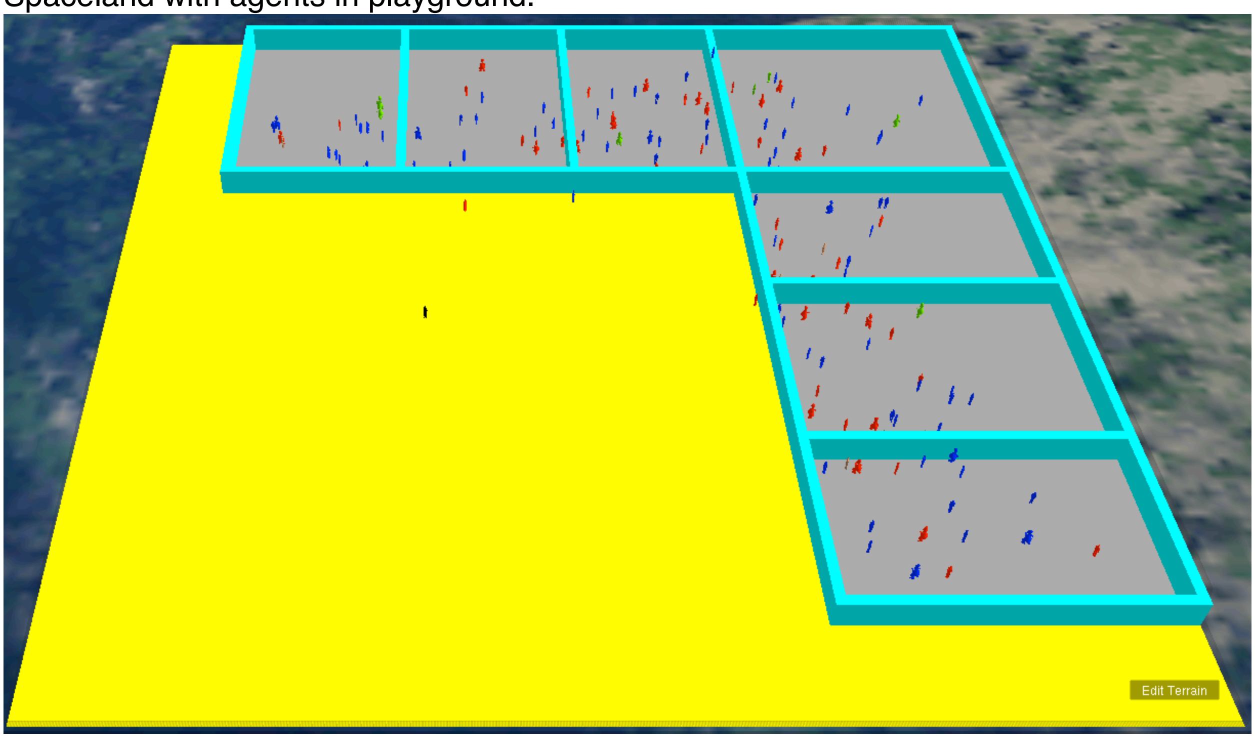

90.0
67.5
45.0
22.5
0
Seasonal
I Got Both
All Grades


Do you cough into your elbow?
# of People Who Cough Into Their Elbow
50.0
37.5
25.0
12.5
0
K
1
2
3
4
5
6
Grade
Yes
No

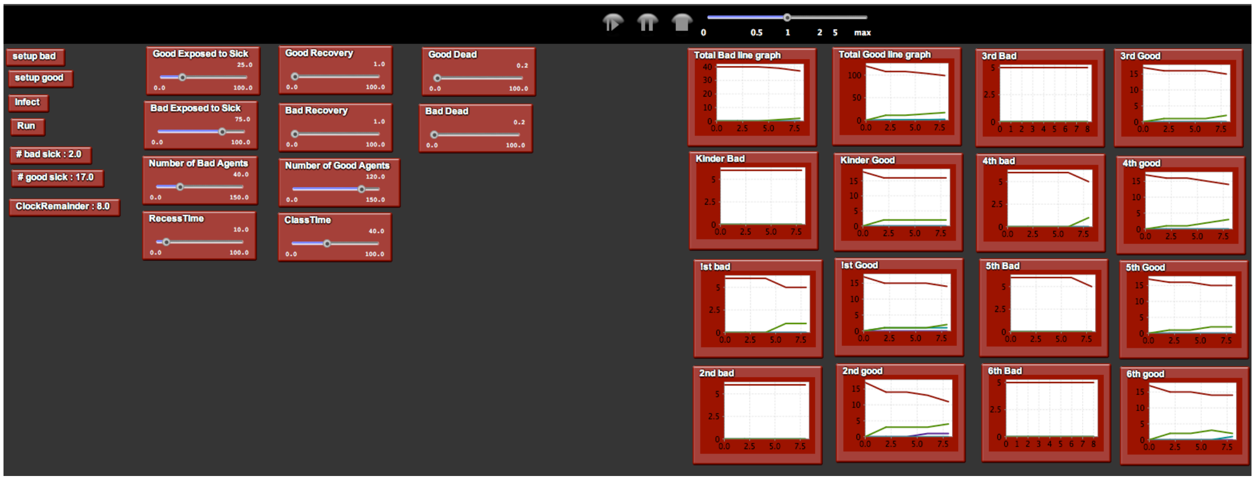

200
150
100
50
0
Yes
No
All Grades



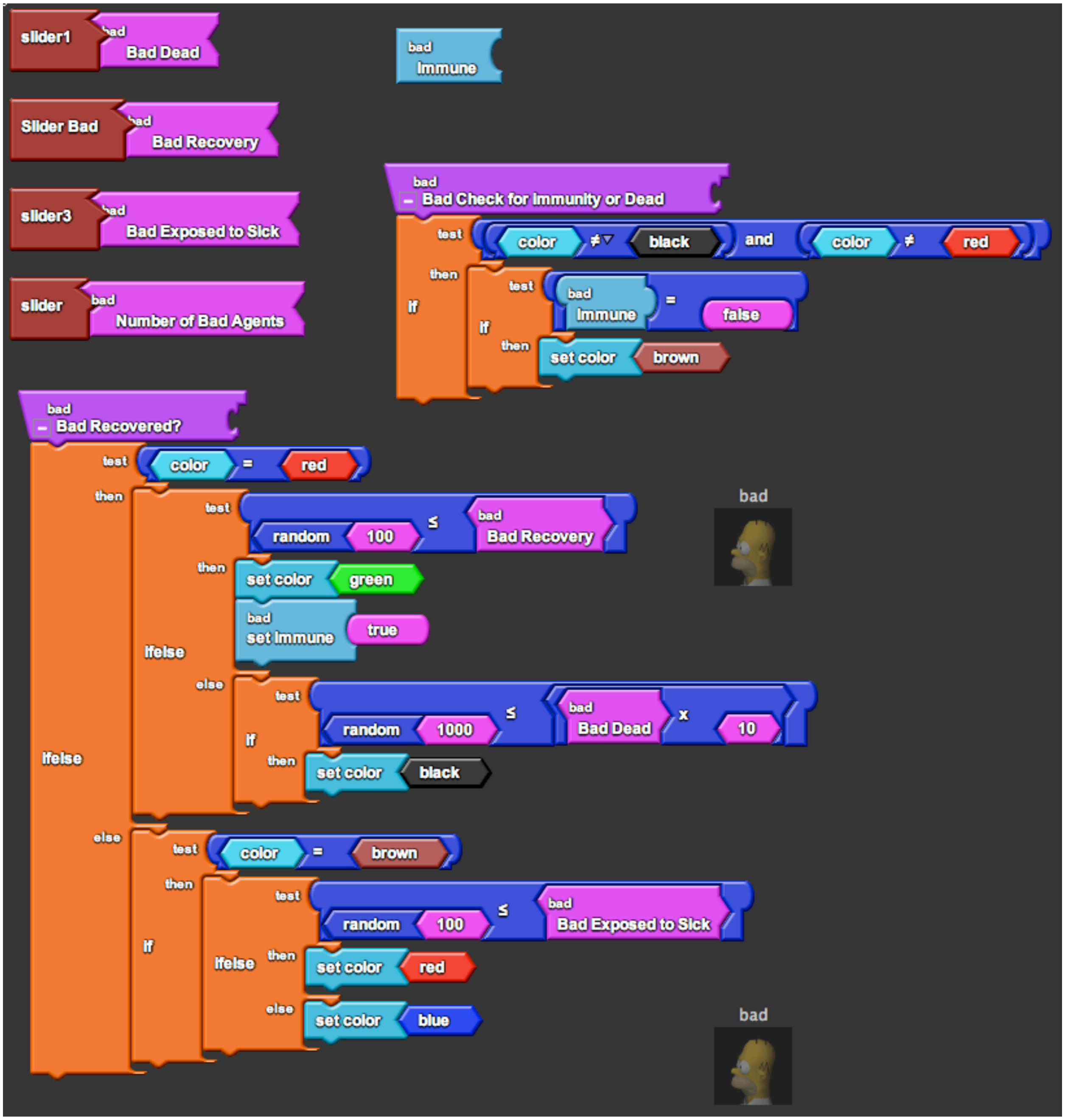
Spaceland with agents in playground.

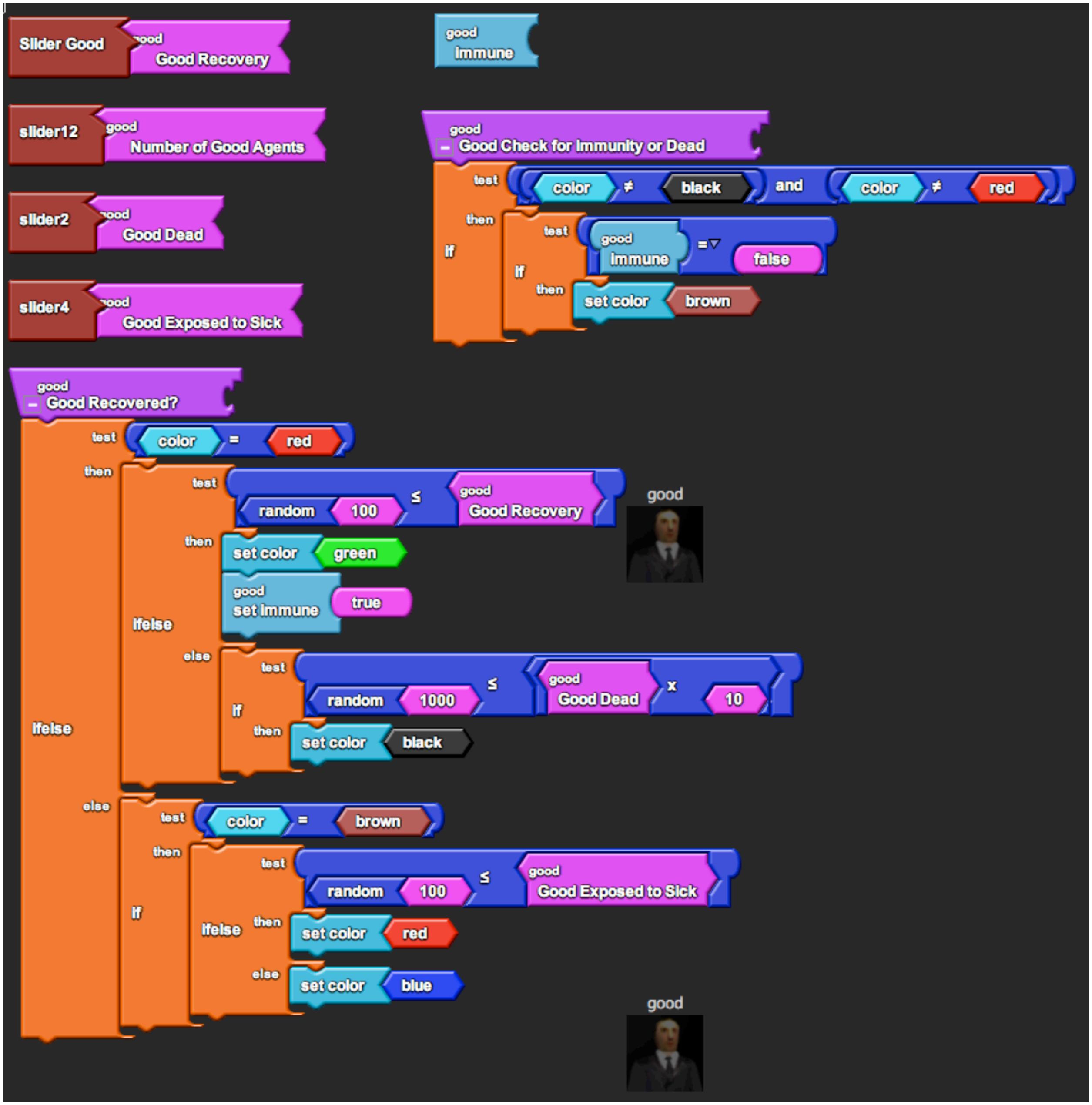


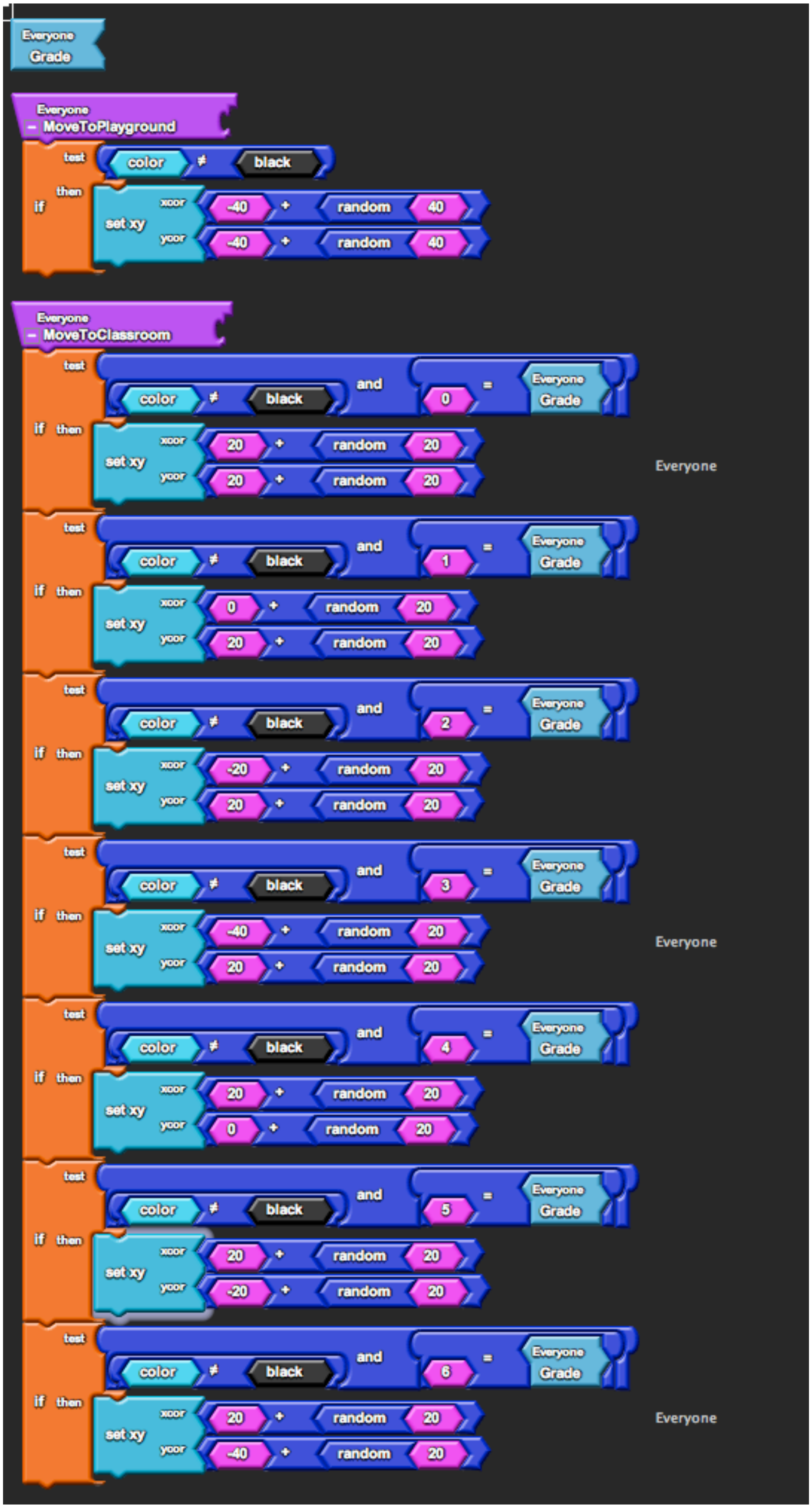
Spaceland with agents in classrooms

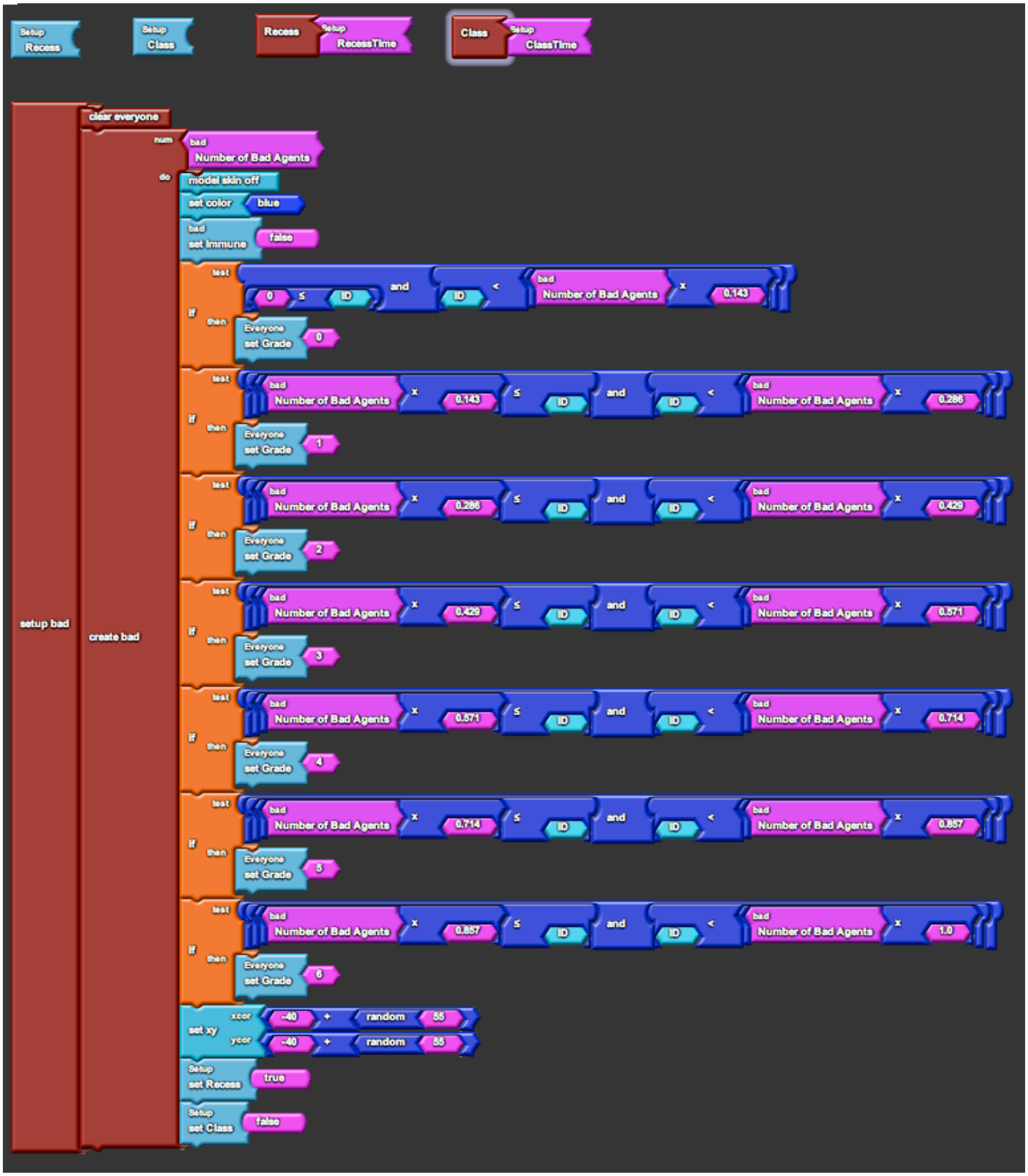


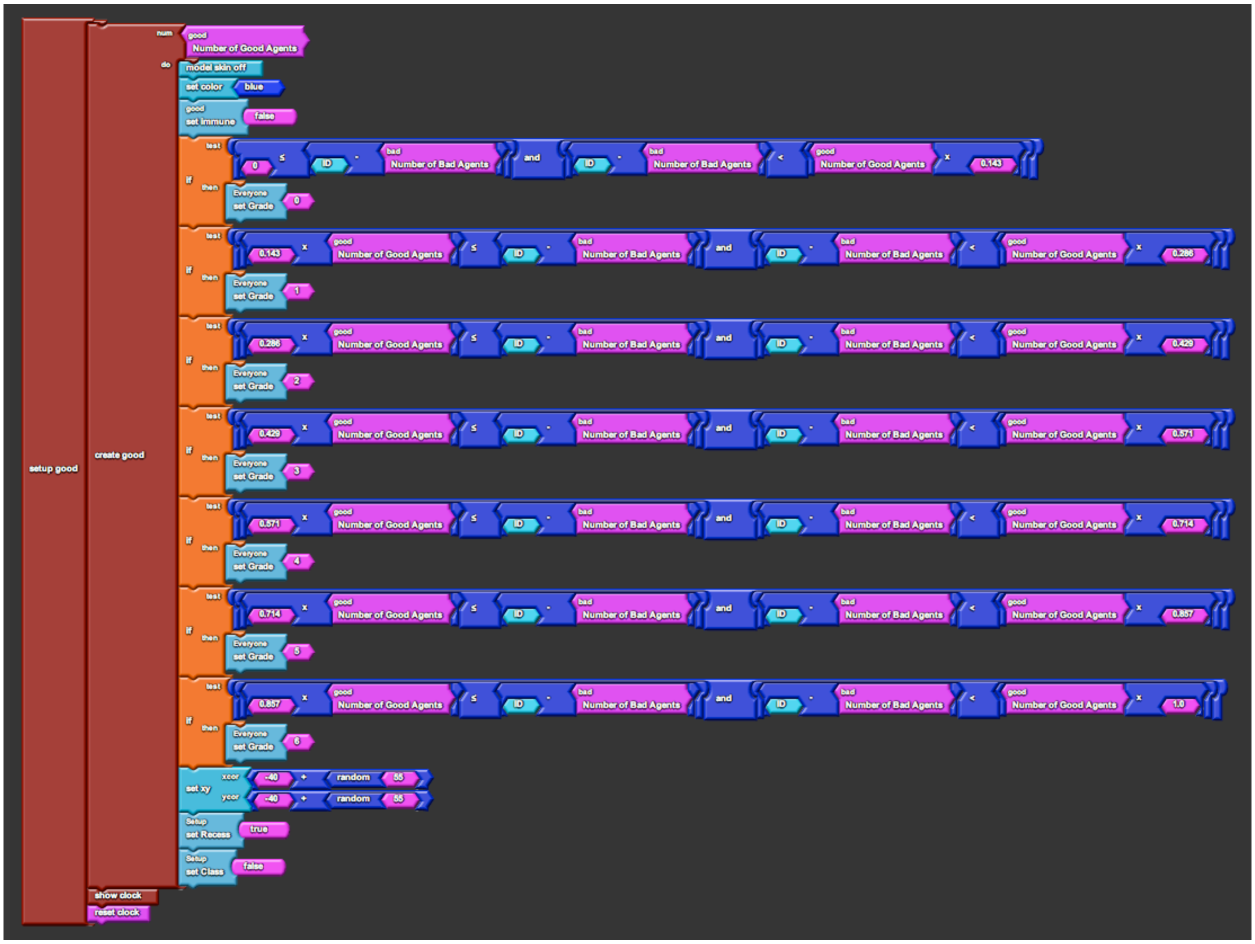
Controls, sliders and graphs.


slider1
bad
Bad Dead
Slider Bad
bad
Bad Recovery
slider3
bad
Bad Exposed to Sick
slider
bad
Number of Bad Agents
bad
Immune
bad
Bad Check for Immunity or Dead
if
test
color ≠ black and color ≠ red
then
if
test
bad Immune = false
then
set color brown
bad
Bad Recovered?
ifelse
test
color = red
then
ifelse
test
random 100 ≤ bad Bad Recovery
then
set color green
bad
set Immune true
else
if
test
random 1000 ≤ bad Bad Dead x 10
then
set color black
else
if
test
color = brown
then
ifelse
test
random 100 ≤ bad Bad Exposed to Sick
then
set color red
else
set color blue
bad
bad

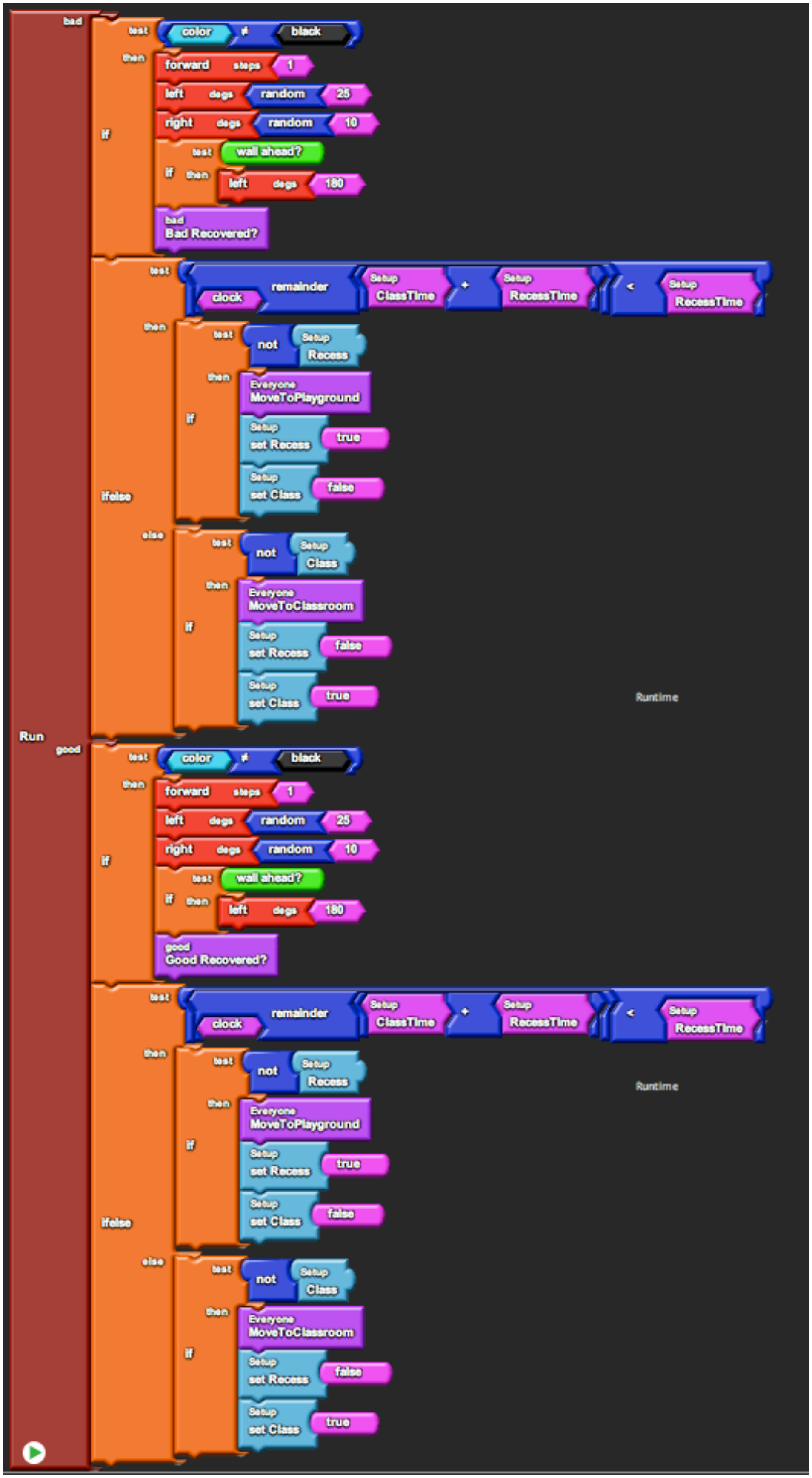

Slider Good
good
Good Recovery
good
Immune
slider12
good
Number of Good Agents
good
Good Check for Immunity or Dead
test
color ≠ black and color ≠ red
then
if
test
good
Immune = false
if
then
set color brown
slider2
good
Good Dead
slider4
good
Good Exposed to Sick
good
Good Recovered?
test
color = red
then
ifelse
test
random 100 ≤ good Good Recovery
then
set color green
good
set Immune true
ifelse
else
test
random 1000 ≤ good Good Dead x 10
if
then
set color black
good
else
test
color = brown
then
if
test
random 100 ≤ good Good Exposed to Sick
ifelse
then
set color red
else
set color blue
good


Everyone
Grade
Everyone
MoveToPlayground
if test color ≠ black
then set xy xcor -40 + random 40
ycor -40 + random 40
Everyone
MoveToClassroom
if test color ≠ black and 0 = Everyone Grade
then set xy xcor 20 + random 20
ycor 20 + random 20
Everyone
if test color ≠ black and 1 = Everyone Grade
then set xy xcor 0 + random 20
ycor 20 + random 20
if test color ≠ black and 2 = Everyone Grade
then set xy xcor -20 + random 20
ycor 20 + random 20
if test color ≠ black and 3 = Everyone Grade
then set xy xcor -40 + random 20
ycor 20 + random 20
Everyone
if test color ≠ black and 4 = Everyone Grade
then set xy xcor 20 + random 20
ycor 0 + random 20
if test color ≠ black and 5 = Everyone Grade
then set xy xcor 20 + random 20
ycor -20 + random 20
if test color ≠ black and 6 = Everyone Grade
then set xy xcor 20 + random 20
ycor -40 + random 20
Everyone


Setup
Recess
Setup
Class
Recess
Setup
RecessTime
Class
Setup
ClassTime
setup bad
clear everyone
create bad
num
bad
Number of Bad Agents
do
model skin off
set color
blue
bad
set Immune
false
if
test
0
≤
ID
and
ID
<
bad
Number of Bad Agents
x
0.143
then
Everyone
set Grade
0
bad
Number of Bad Agents
x
0.143
≤
ID
and
ID
<
bad
Number of Bad Agents
x
0.286
Everyone
set Grade
1
bad
Number of Bad Agents
x
0.286
≤
ID
and
ID
<
bad
Number of Bad Agents
x
0.429
Everyone
set Grade
2
bad
Number of Bad Agents
x
0.429
≤
ID
and
ID
<
bad
Number of Bad Agents
x
0.571
Everyone
set Grade
3
bad
Number of Bad Agents
x
0.571
≤
ID
and
ID
<
bad
Number of Bad Agents
x
0.714
Everyone
set Grade
4
bad
Number of Bad Agents
x
0.714
≤
ID
and
ID
<
bad
Number of Bad Agents
x
0.857
Everyone
set Grade
5
bad
Number of Bad Agents
x
0.857
≤
ID
and
ID
<
bad
Number of Bad Agents
x
1.0
Everyone
set Grade
6
set xy
xcor
-40
+
random
55
ycor
-40
+
random
55
Setup
set Recess
true
Setup
set Class
false


setup good
create good
num
good
Number of Good Agents
do
model skin off
set color
blue
set immune
false
test
if
then
Everyone
set Grade
0
1
2
3
4
5
6
0.143
0.286
0.429
0.571
0.714
0.857
1.0
Number of Bad Agents
ID
and
set xy
xcor
ycor
-40
random
55
Setup
set Recess
true
set Class
show clock
reset clock


Infect
bad
good
if
test
then
random
100
≤
10
set color
red



Run
bad
if
test color ≠ black
then
forward steps 1
left degs random 25
right degs random 10
if test wall ahead?
then left degs 180
bad
Bad Recovered?
ifelse
test clock remainder Setup ClassTime + Setup RecessTime < Setup RecessTime
then
if
test not Setup Recess
then
Everyone MoveToPlayground
Setup set Recess true
Setup set Class false
else
if
test not Setup Class
then
Everyone MoveToClassroom
Setup set Recess false
Setup set Class true
Runtime
good
if
test color ≠ black
then
forward steps 1
left degs random 25
right degs random 10
if test wall ahead?
then left degs 180
good
Good Recovered?
ifelse
test clock remainder Setup ClassTime + Setup RecessTime < Setup RecessTime
then
if
test not Setup Recess
then
Everyone MoveToPlayground
Setup set Recess true
Setup set Class false
else
if
test not Setup Class
then
Everyone MoveToClassroom
Setup set Recess false
Setup set Class true
Runtime


Collisions bad
Collision bad
test
If then
color of ID collidee = red
bad
Bad Check for Immunity or Dead
test
If then
color of ID collidee = red
bad
Bad Check for Immunity or Dead
Collisions bad
Collision good
test
If then
color of ID collidee = red
bad
Bad Check for Immunity or Dead
test
If then
color of ID collidee = red
good
Good Check for Immunity or Dead
Collisions good
Collision good
test
If then
color of ID collidee = red
good
Good Check for Immunity or Dead
test
If then
color of ID collidee = red
good
Good Check for Immunity or Dead