When Pigs Fly

New Mexico Supercomputing Challenge

Final Report

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Team #40

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Executive Summary

Our project is a simulation of what would happen if an epidemic of swine/avian flu hit a certain place. We started this project because of an article that we read (Discover, Flu Wars 40). In Indonesia, the avian flu virus is a big problem. With the easily spread swine flu traveling the globe, scientists were beginning to worry that a swine/avian flu hybrid would form. A hybrid like that could cause an epidemic like the 1918 pandemic that killed between 25-40 million. Our project will show the best ways to control the spread of this virus that could appear in the near future.

Our team began to research the infection rate for the swine flu (H1N1) and the death rate of the avian flu (H5N1.) We decided to use the worst case scenario of the H1N1 flu’s 80% infection rate and the H5N1 flu’s 50% death rate. (*Avian Influenza CDC)* We want to run four simulations testing quarantine, masks, vaccines, and a control.

We used the program Starlogo TNG to simulate our experiment. After reviewing the results from different simulations we came to a conclusion. Vaccines were ineffective because we required a six month development period. Quarantine was very effective having the highest agent survival rate. Should an epidemic start the first thing I would do is to quarantine the infected and to pass out masks.

Introduction

Diseases and plagues have been a part of human life through history. They are caused by fungi, viruses, bacteria, and parasites. They are passed person to person and transmitted by animal and insects bites. They can also be transferred by touching contaminated items. There are many different types of diseases, and each must be treated in different ways. Some can be transmitted by air, on objects, and in food while some are harder to get, like AIDs. They can also be spread from animal to human and from animal to animal.

Epidemics are a wide spread case where many people get a disease. These pandemics like the Black Death usually kill thousands to millions of people, like in the case of the 1918-1919 pandemic. An estimated 28% of all Americans got infected, striking people 20-40 years old the hardest. As with the other pandemics, it spread around a large area (the world) because of people traveling from place to place.

Viruses must spread from host to host to survive. This means that the virus must have a steady stream of new victims, and should it get them, then it could cause a pandemic. However, if the host and others develop immunity then the virus would be unable to infect others. If people survive the diseases then they would have immunity. This is why vaccines are effective. They allow people to acquire immunity without actually getting sick. Vaccines can be used to wipe out entire diseases if used right.

Viruses have to constantly evolve and change to survive, sometimes by evolving or mutating into a slightly different virus to fool immune memory. DNA viruses, however, rely on their ability to spread because they don't evolve or mutate quickly. An example is smallpox. When people were given vaccines the virus couldn't evolve fast enough to breach immunity.

RNA viruses like influenza evolve slightly faster than DNA viruses. They travel around the world, infecting people and following the flu seasons. When it once again reaches the starting point, then it's mutated to get past the immunity. The CDC watches the flu and makes sure there are vaccines for it. Sometimes two viruses can meet in the same cell and combine, creating a new virus that has traits from both. For example, if a farmer gets infected with the swine flu and the avian flu at the same time, then they could both combine, although it's not likely. It has occurred, however, about once every 16 years. The CDC continually monitors viruses, and in 1976 they found one of these changes and had the US population vaccinated against it. The virus died out before starting an epidemic. In 1977, several people died of a flu that came from chickens in Hong Kong. All the chickens in China were killed to stop the spread. It is not known if these precautions stopped the virus, or if the virus wouldn't have spread anyway.

Description

Swine flu is currently spreading rapidly among humans. Avian flu is very deadly but only spreads from birds to humans when they are in close contact. Flu viruses are always mutating and if these two viruses combine, it could result in a deadly, easily spread disease. This mutated super flu could cause widespread devastation. The goal of our project is to find the best ways of stopping the spread of a deadly new flu strain.

We are investigating how a disease would spread from one person to another and how to contain the disease. We will not show where the disease came from or how people got infected, just how the infection spreads.

We began with 300 agents, out of which 10% were infected. We ran three simulations and a control. They are quarantine, masks, and vaccines. In the quarantine simulation, the agents head to and are trapped in a box in the corner away from others. We simulate masks by using a lower infection rate of 40% rather 80%. In the vaccine simulation, the vaccines make anyone they touch immune after a development period of six months. We ran a few tests with the experimental project and made some changes. Please see our programming code commentary in Appendix A for more details about the procedures we used.

Results

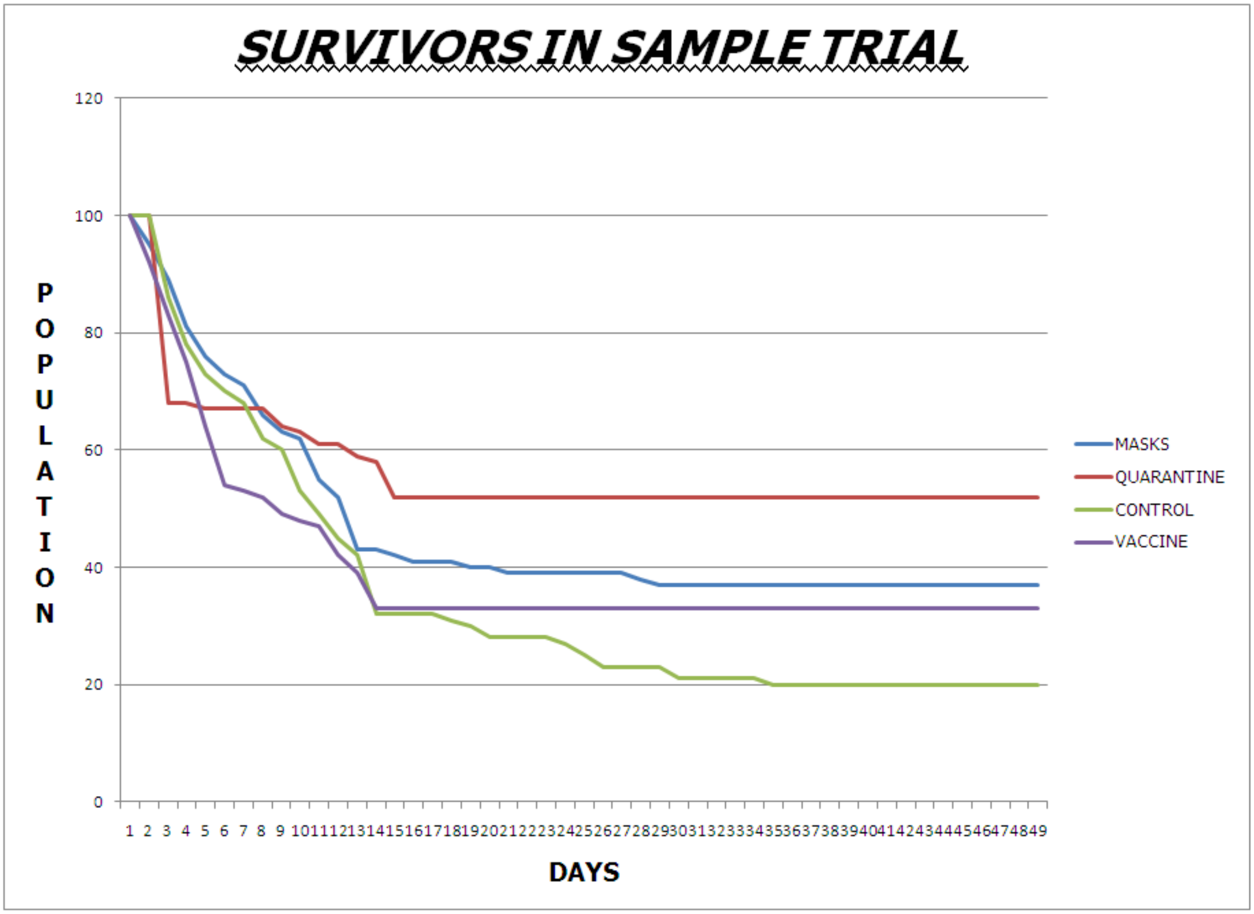
Our first results for the quarantine simulation were that 32 people survived. Our results for the masks simulation were that 27 people survived. Results for the vaccine simulation were that 9 people survived. For a control with no intervention 29 people survived. We ran each simulation 3 times and averaged the number of survivors together. We noticed that the numbers were all close to 30 for every simulation, so we revised our code. We did not believe those results were valid.

We noticed that in each simulation, the starting number of infected agents affected the outcome more than anything else. We decided to set the starting number at 10 infected agents rather than a random 10%. We also changed the speed of the agents' movement from 3 steps to 1 step. This helped to slow the infection rate. We reduced the number of agents to 100. We then moved the quarantine area to the center of space land, so the agents could reach it without infecting too many other agents. This made our quarantine much more effective. After reviewing our masks data, we decided to change the infection rate to 20% from 40% to match our research.

After these changes, here are the numbers of survivors out of one hundred.

	Quarantine	Masks	Vaccine	Control
Trial 1	62	34	16	20
Trial 2	41	22	13	14
Trial 3	65	26	29	10
Average	56	27	19	15

Table 1



Graph 1

Conclusion

In our simulation, the quarantine and masks were the most effective in preventing infections and saving lives. Vaccines were useless, because it took too long for vaccines to develop. We believe that the best thing to do would be to combine masks and quarantines.

We expected that the quarantines would be effective because if the infected are contained they can't infect others. Quarantine works best when there is a central location, such as a hospital or school, which everyone can reach easily. Also, healthy people need to stay away from that spot or they might become infected. Our results for the simulation using masks were also expected, because according to our research, the masks reduce infection rate. It surprised us that the infection rate did not have as big an effect as we thought. For example, reducing the infection rate from 0.8 to 0.2 resulted in an average of only 12 more survivors. Our research showed that some people in real life situations didn't wear masks consistently. It was also suggested that sick people could wear masks along with those treating them.

Vaccines are only effective if they are almost ready before the epidemic. This would cut down the waiting period so the vaccines would be ready when the epidemic starts. In our simulation, we programmed vaccine development to take six months, as our research showed. When we look at real world data, vaccines are effective because the scientists predict which viruses are coming and have vaccines ready.

If an epidemic did happen, then the first thing we would do is set up a quarantine area for those who became infected. We would distribute masks to cut down on the infection rate, and warn everyone to stay away from each other. We would close schools and other public gatherings to stop the virus from spreading.

Recommendations

We recommend that you run the program at least 10 times. You would also want to make it so that no agents start on the same square since humans wouldn't start out on top of each other. Also, the agents should try to avoid each other.

We would advise other teams to get to know and work closely with their mentor.

Our best accomplishment is learning to program in StarLogo and constantly improving and changing our program. We are also proud about how we managed to meet all the deadlines and work together as a team.

Acknowledgements

Nick Bennet and Dale Henderson, for visiting our school and helping us learn to program.

Christopher Hoppe, mentor.

Mrs. Dray, our principal, for providing transportation for our field trips and letting us take days off school to go.

Our parents, for transportation and their support.

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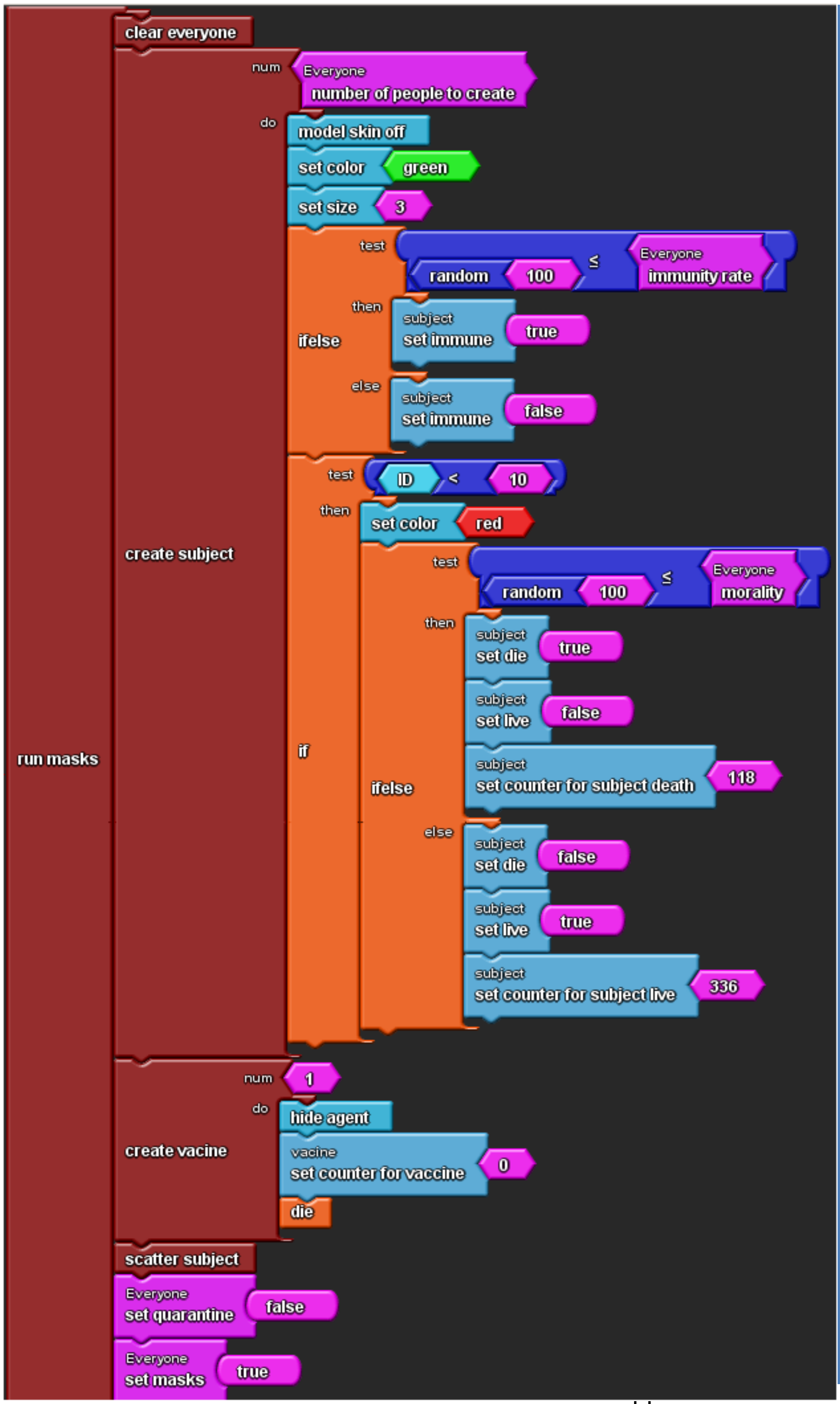
Appendix A

Program Code

Figure 1



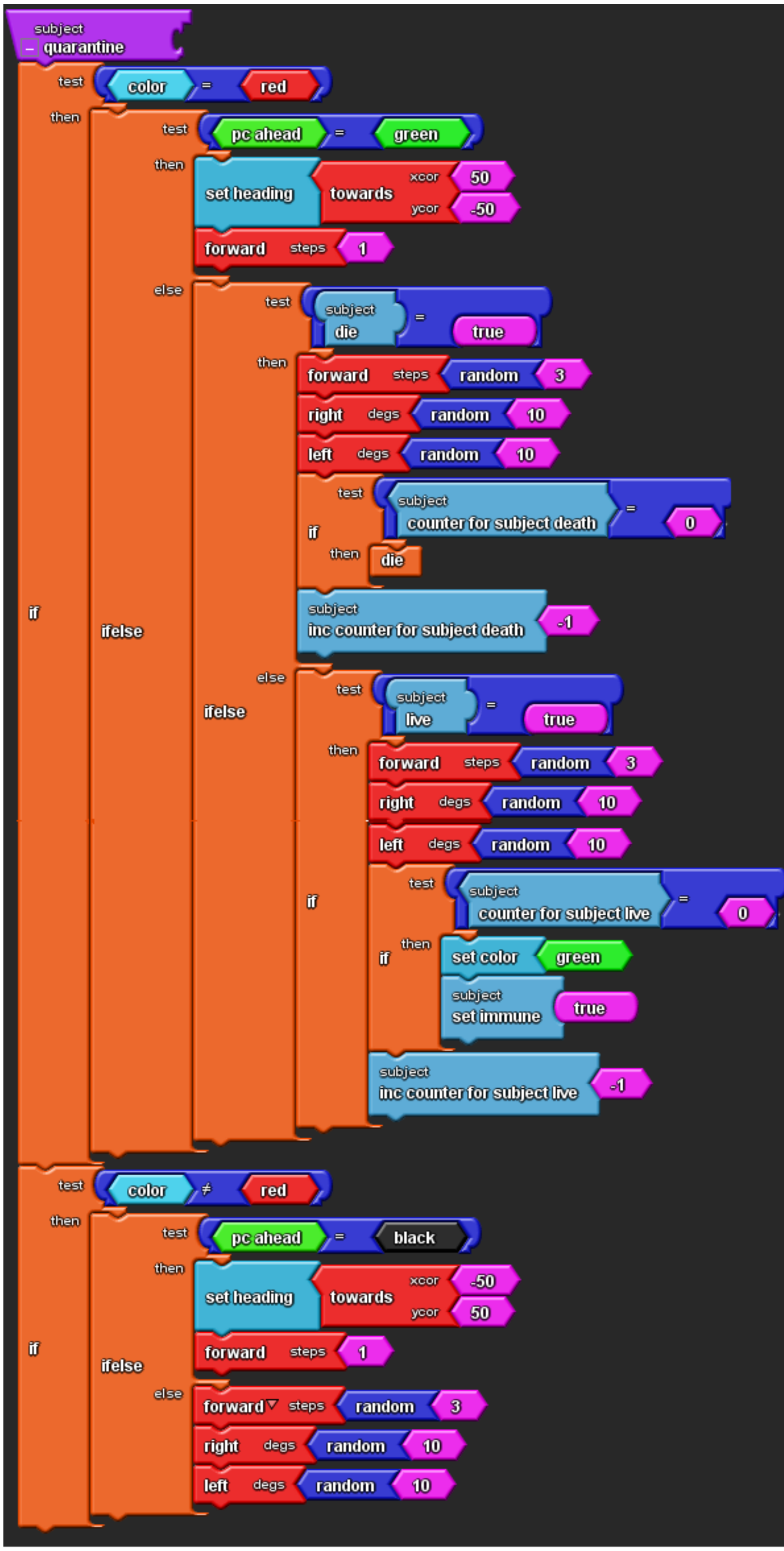
Set Up Masks & Quarantine

This creates people.

They have a chance to be immune based on the immunity rate.

Then 10 of them become sick and have a 50% chance to live or die because the mortality rate of avian flu is 50%.

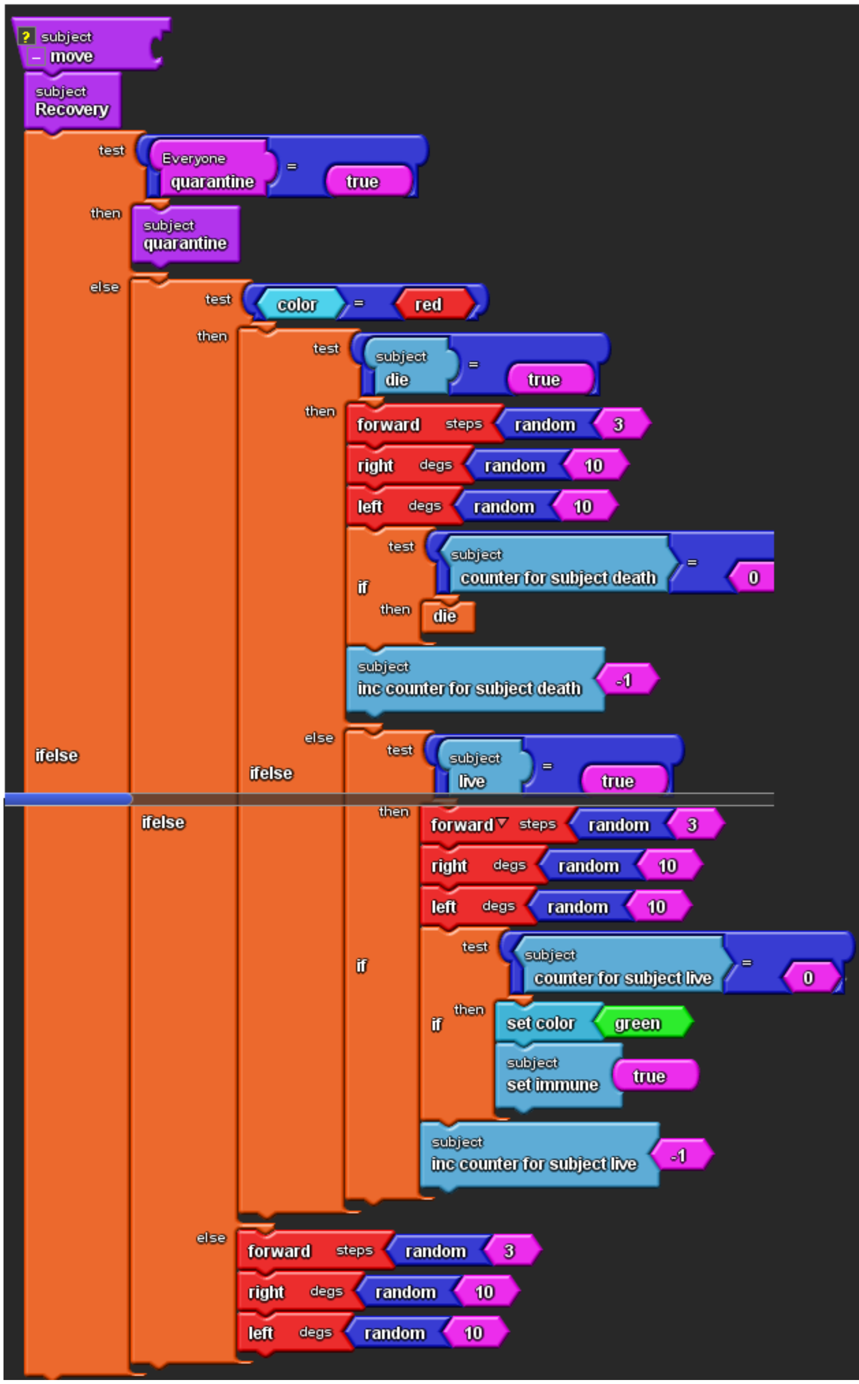
Figure 2



Quarantine module

If you are not in the quarantine zone and you are sick this tells you to go to it.

If you're in the quarantine zone and not sick this makes you leave.



Move module

This module runs quarantine

When this equals 0 the agent is dead

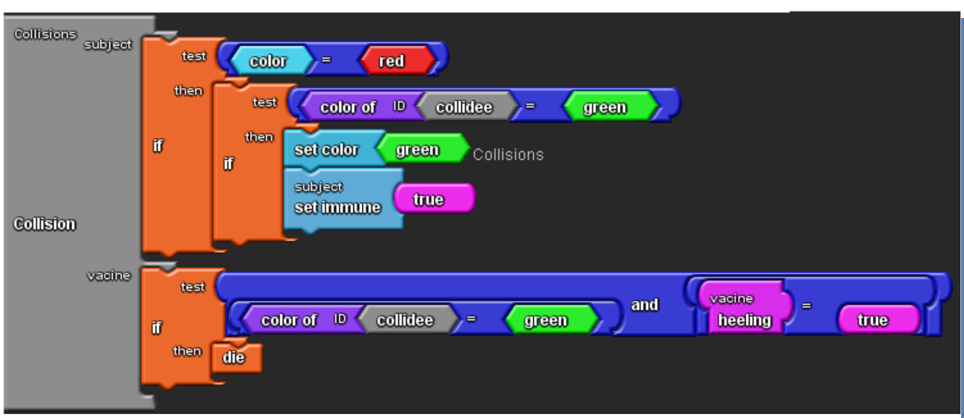
This is the counter for recovery

When this equals 0 the agent becomes healthy

Figure 3

When the counter reaches 6 months the vaccines can heal people.

Figure 4



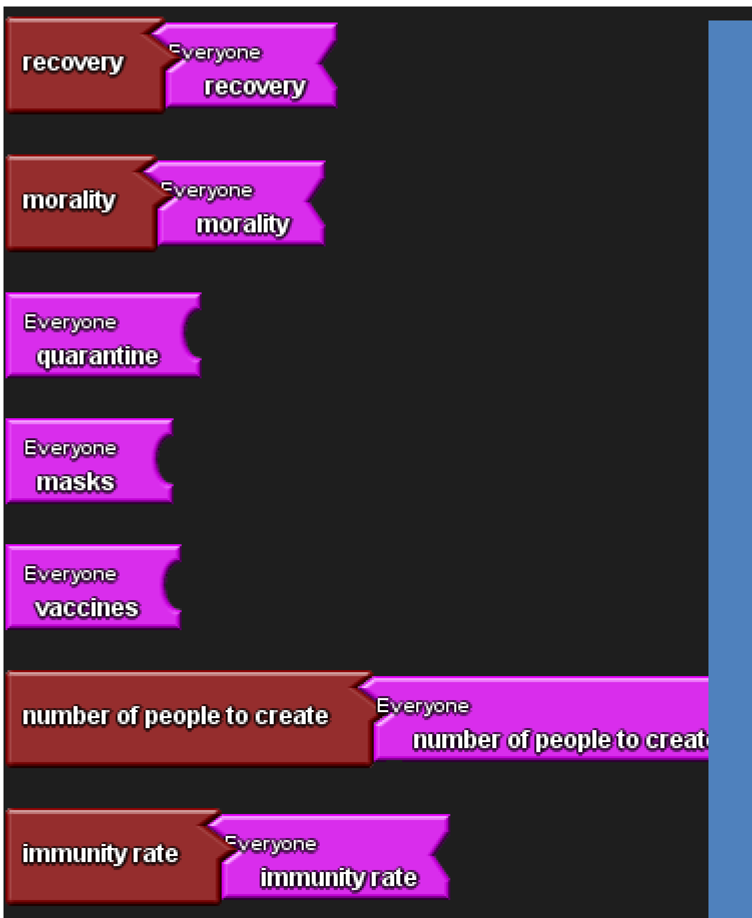
When they collide with a vaccine that has the ability to heal people, agents get well.

Figure 5

Figure 6

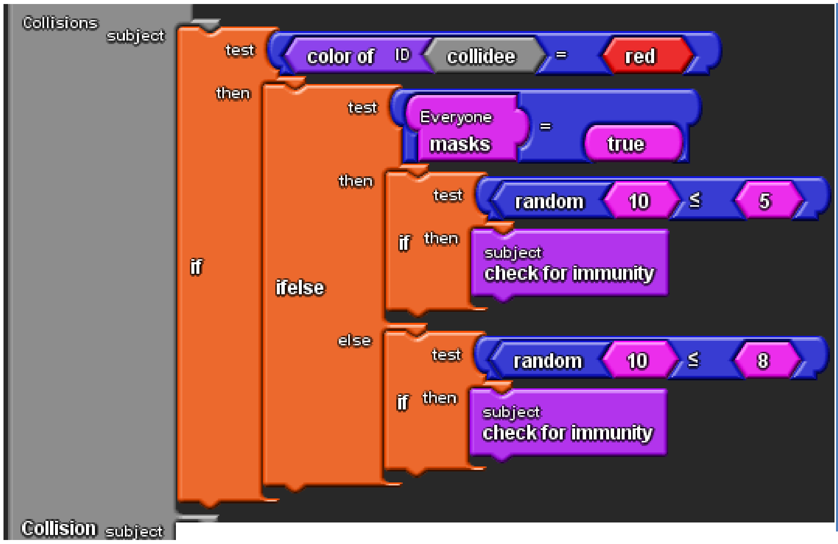
Recovery

This makes them live. After time counts down they are no longer sick



Global variables

Figure 7



If running masks, this code lowers infection rate.

Figure 8