Cholera Outbreak in Haiti

New Mexico
Super Computing Challenge
Final Report
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Team 37
Desert Academy

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Executive Summary

After the earthquake in Haiti in mid January 2010, a cholera epidemic spread through the already impoverished country. The goal of our project is to model the spread of the epidemic applying our knowledge of epidemiology programming. Through doing this we hope we can develop a better understanding of how the disease spreads so that we have the option to expand on our project in the future.

Introduction

A. Objective

The objective of our project is to accurately model the spread of cholera through out the earthquake relief camps in Haiti. To do this, we are gathering data regarding susceptibility, infection, and recovery and applying our knowledge of epidemiology.

B. Purpose

We chose this project because we are interested epidemiology and thought it would be interesting to work with a current problem that is very important to a lot of people. We have worked with epidemiology before and created very successful models so we know what type of programming to apply.

C. Hypothesis

Our hypothesis is that if we can collect accurate and appropriate data from the earthquake relief camps and incorporate it into our model in a realistic way, we will be able to create a model that realistically depicts the spread of cholera throughout the earthquake relief camps in Haiti.

D. Biology

Cholera is derived from the bacterium *vibrio chloerae*, and is spread through the consumption of food and water infected with the bacterium. Cholera, if not treated immediately, is fatal and can kill within hours. The bacterium causes an acute diarrhoeal infection. The symptoms are severe dehydration and diarrhea. [1]

Despite the fatalness of Cholera, it is easily treated. Eighty percent of cases can be treated successfully with oral rehydration salts. The reason so many people in Haiti are not being treated is their lack of resources and sterile materials. The epidemic is spreading very quickly because of this and as of January 13, 2011, 3,759 people were dead, 181,000 were infected, and only 101,000 were being treated in hospitals.

The most effective way to prevent a cholera outbreak is to maintain sanitary living conditions. It is very important that clean water is constantly provided. Oral Cholera vaccines can be provided. But should be in addition to sanitary conditions.

For a cholera outbreak to occur, there has to be significant breaches in water sanitation and hygiene infrastructure used by groups of people, permitting large-scale exposure to food or water contaminated with *vibrio chloreae* organisms and there has to be cholera present in the population.

After the earthquake in Haiti, the relief camps had very poor sanitary conditions, so cholera spread easily throughout the population. Relief workers that came in after the outbreaks immediately started providing sanitary water in an attempt to stem the spread of the disease.

There are two serogroups of the bacterium that cause outbreaks. They are O1 and O139. *Vibrio chloerae* that are not O1 and O139 can still cause mild diarrhea, but are not capable of starting epidemics. [5]

E. Background

In January 2010, a 7.0 magnitude earthquake struck Southern Haiti. The earthquake, which killed around 316,000 people and left 1,000,000 homeless, forced the Haitians to move into crowded relief camps. On October 21, 2010, a cholera outbreak was confirmed.

Cholera has not been present in the Haitian population for decades, so it is unclear how it was re-introduced. One theory is that United Nation troops from Nepal, where a similar strain of cholera is endemic, introduced the bacterium when they came to do relief work after the earthquake. The UN is denying this accusation, but Swedish Ambassador Claes Hammar confirmed the rumor, saying "I consider my source to be a reliable one. It is a US official, but I cannot say who"

During the 19^{th} century, cholera spread rapidly throughout the world. There were six pandemic strains that killed millions of people. Every year, there are aproximatley 3-5 million cholera cases, resulting in 100,00-120,00 deaths. [5] Choler has been very prominent in world history.

Description

A. Limits

The main limit on our project was time. Had we had more time, we could have done a lot more research and created a more detailed code to program a more accurate depiction of the spread of cholera through the relief camps in Haiti. Another limitation on our project was our coding ability, if we knew how to efficiently use Net Logo, we could probably have created a more powerful, accurate model.

B. Future Development

In the future, we would like to elaborate on our model and program possible ways to stop the spread of the disease. We could develop different solutions and test which stops the spread of the disease most efficiently. We would also like to improve the accuracy of the model and do more research to make the entire project more realistic. It would also improve our model to move it to a more powerful and accurate program, such as Net Logo like we had initially planned.

C. Model

We wanted to model how cholera would affect a city, specifically Haiti, but we decided to model a single relief camp to simplify the project and because cholera is mainly spreading through relief camps.

Our model shows a relief camp with agents moving around it. On of the most important variables is the shared number called thirst. When an agent's thirst dropped to zero they have look for a well to drink from. Drinking causes the thirst variable to increase its value so the agent can continue walking. If an agent drinks from a contaminated well, they have a chance of being infected with cholera. There is another shared number variable called energy. An infected agent looses energy until they are to sick to move and get water. When this happens, the agent stands still until they loose all their energy, which results in their death. This loss of energy represents suffering from severe diarrhea and dehydration. Before an agent was immobilized by their loss of energy, they would have a chance to heal by themselves and if they became healthy, they would be immune to cholera.

To make this model more realistic, if a certain number of people drank from the contaminated water they would figure out that it was contaminated and close it off. Another addition was for there to be a chance that the contamination would spread to other wells. There is another agent who represents a doctor. He is told to find weak agents and heal them.

For this model to accurately show how Cholera would spread through a Haitian relief camps all of the variables have to be right. In this type of model variables are really important. These are the most important variables that we needed to get right were the chance of getting infected, the chance of spreading

Cholera to another well, the chance of recovering without help, and the chance of a well being blocked off. We tried to take as many factors as we could into account, such as the fact that no one would be immune to cholera, because it had not been present in the Haitian population for decades.

The way my variables work isn't the most realistic way. For instance the likelihood of getting infected by drinking contaminated waters is if random 2=1 the agent gets infected. This works well for that example, but for a person infecting a well the likelihood is if random 10>9 then the well gets infected. The problem is that one well could get infected with one contact with a person and another well could take 15 before it is infected therefore each run of the model makes a slightly different scenario. It would have been better if we could have found a better way of modeling the variables so there wouldn't be such a range in the outcome of the model. We'd like to improve the model by using another program so the variables would work out better or I could try to figure out something better in Star Logo.

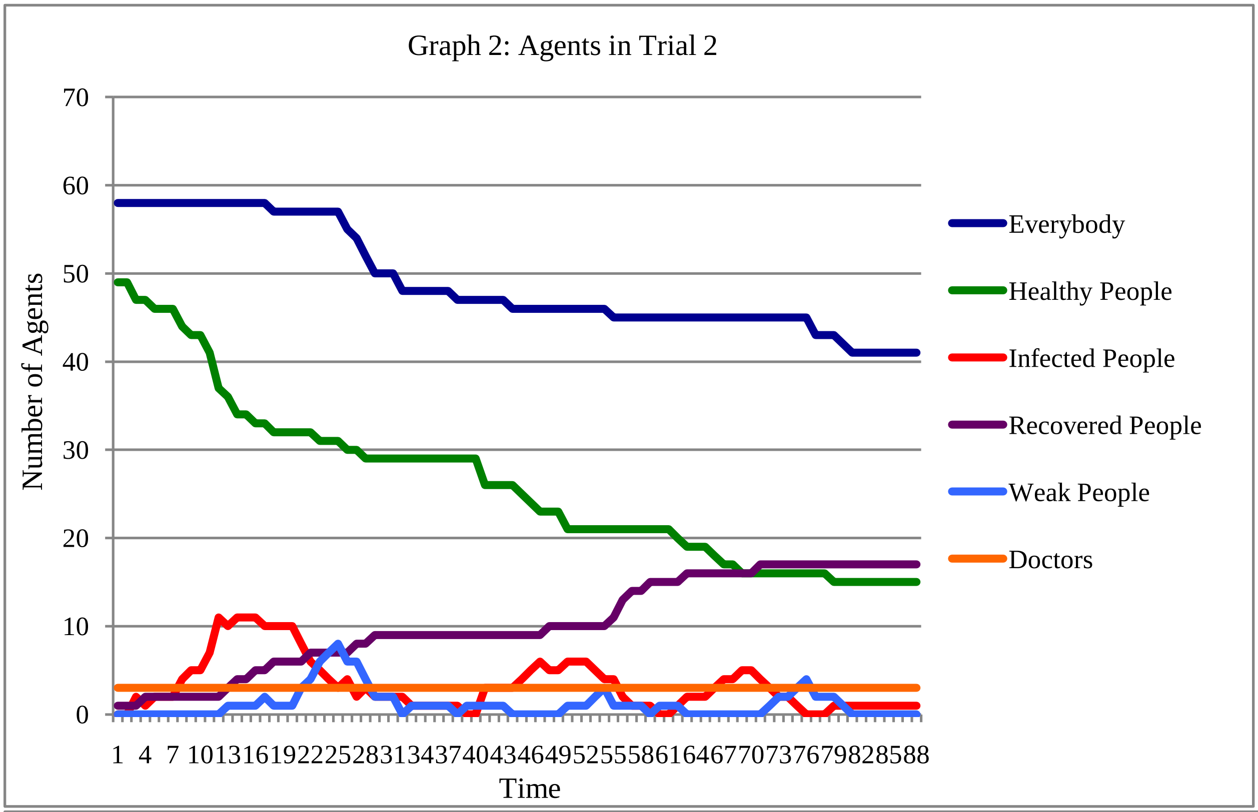
Results

Our results are presented in graphs based of the data collected during running the model. In our model, around sixty people start off healthy and every time we ran the model around thirty agents got infected. About fifteen agents die, and the rest of them recover. The fatalities and the people who survived are supposed to match what is actually happening in Haiti's earthquake relief camps.

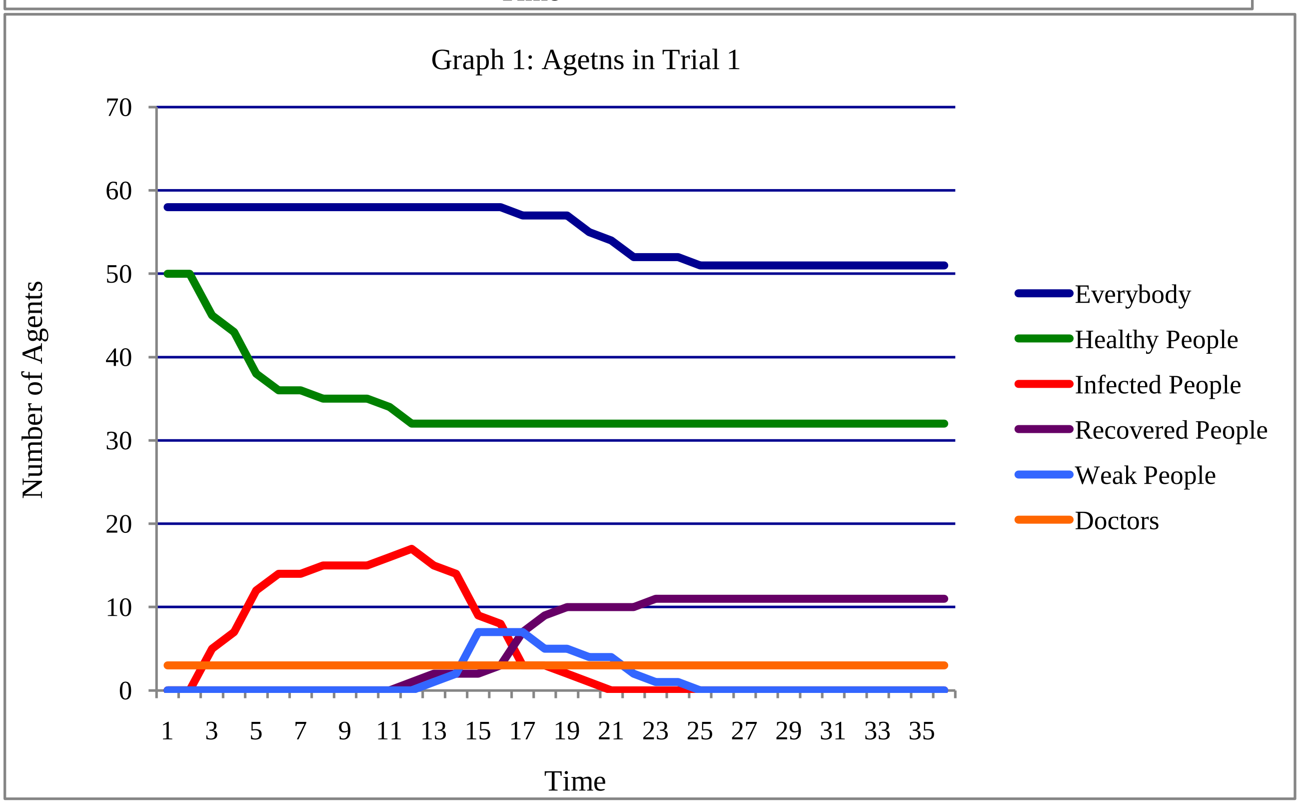
In our model, if an agent drinks from an infected well, they get sick. After a while, enough people use the well and they close off the well to prevent further contamination. Usually, an agent contaminates another well and before that well is stopped and around 30 people are infected and every once in a while someone gets too weak to move and either gets healed or dies. Some people just heal by themselves and eventually all contaminated wells and infected people are gone which is when the epidemic is over.

The length of time before everything is uncontaminated varied slightly in the different times we ran the model, but the important thing is that the length of time represents how long the epidemic in Haiti will last. The time the model takes to run is usually around a couple of minutes. The length of time changes a lot because sometimes no other wells get infected so not as many people get infected and sometimes all the wells get infected so a lot more people are infected.

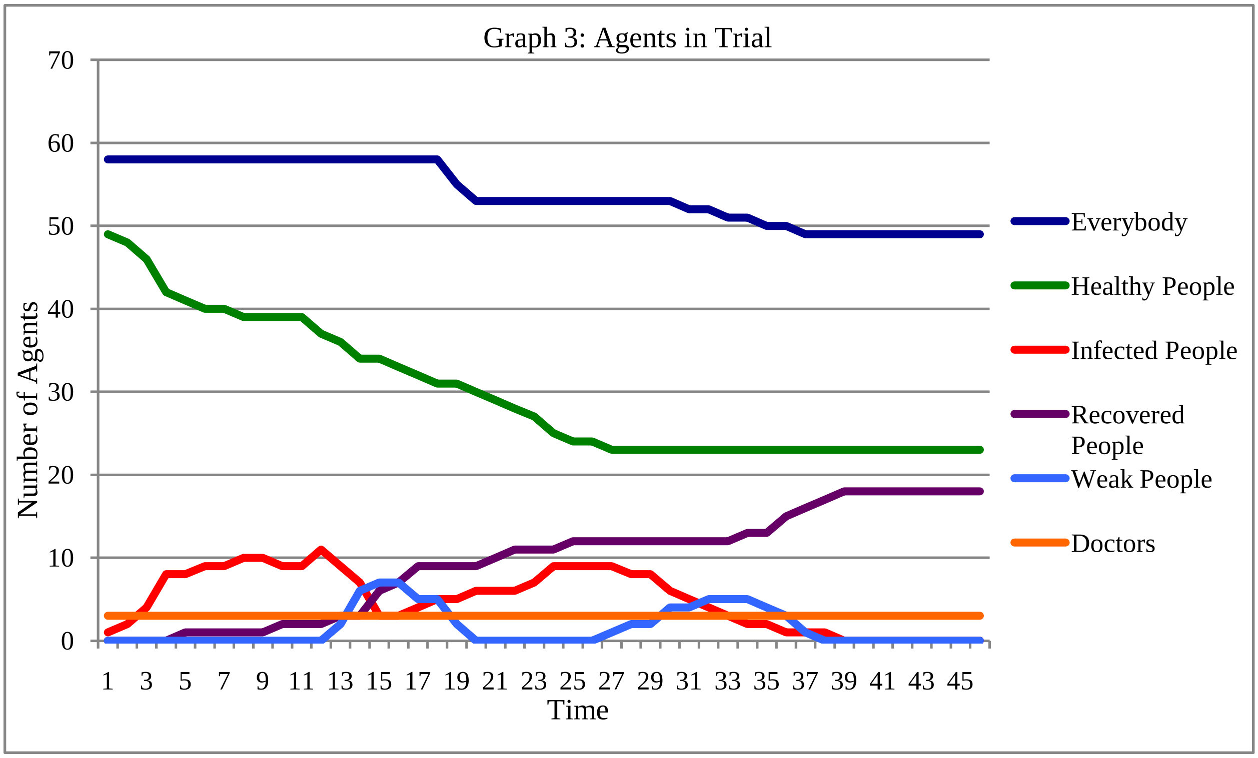
B. Graphs



Graph 2: Agents in Trial 2
70
60
50
40
30
20
10
0
Number of Agents
1 4 7 101316192225283134374043464952555861646770737679828588
Time
Everybody
Healthy People
Infected People
Recovered People
Weak People
Doctors



Graph 1: Agetns in Trial 1
70
60
50
40
30
20
10
0
Number of Agents
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Time
Everybody
Healthy People
Infected People
Recovered People
Weak People
Doctors


Graph 3: Agents in Trial
Number of Agents
70
60
50
40
30
20
10
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45
Time
Everybody
Healthy People
Infected People
Recovered People
Weak People
Doctors

Conclusion

Our model provided use with interesting data regarding the spread of cholera throughout an earthquake relief camp in Haiti. It was not as accurate as we would have liked, but it was still successful. If we continue this project next year, we will improve our model using the ideas previously stated in Future Development on page 7. Our goal was to accurately model how cholera spread. If we had been able to incorporate the more detailed information we collected from research into our model, it would have been more realistic. An example of this is that we did a lot of research on the effects of cholera, but we had a hard time incorporating this. The most significant achievement of our project was creating a model that semi-accurately depicted how cholera spread.

Every time we ran our model, it eventually got to a point where all the infected wells were shut down and everybody was either healthy, recovered, or dead. We could apply this observation to the current situation in Haiti, and conclude that if there is no access to all the infected food and water, and people are treated as efficiently as possible, there is a possibility o stopping the spread of cholera in Haiti. Every time we ran our model, the time it took to end the epidemic varied due to the behavior of the agents. Our model did not accurately depict the extremely unsanitary conditions of the earthquake relief camps, or the extreme population density. If we found a way to add these features, it would increase how realistic our model is.

Another thing we found in our model was how quickly cholera can spread once humans have access to an infected well. This was very interesting and proved again that it is very important to remove food and water infected with water immediately. If we continue this project, it would be very interesting to develop a more realistic depiction of the shutting down of wells.

Our project produced interesting data, and gave us a good basis if we decide to continue next year.

Bibliography

[1] Coleman, William, "Cholera", Chelsea House Publisher, 2003

[2] "CDC-2010 Haiti Cholera Outbreak: Cholera Confirmed in Haiti" *Centers for Disease Control and Prevention*, 22 Oct. 2010, http://www.cdc.gov/haiticholera/situation/

[3] "Cholera Situation Spiraling Out of Control in Haiti" *Helsingin Sanomat*, 18 Nov. 2010, http://www.hs.fi/english/article/Cholera+situation+spiralling+out+of+control+in+Haiti/1135261737531

[4] "Haitians Infected With Deadly Cholera Disease Outbreak", *News Hot Ram*, 23 Oct. 2010, http://www.newshotram.com/haitians-infected-with-deadly-cholera-disease-outbreak/225012/

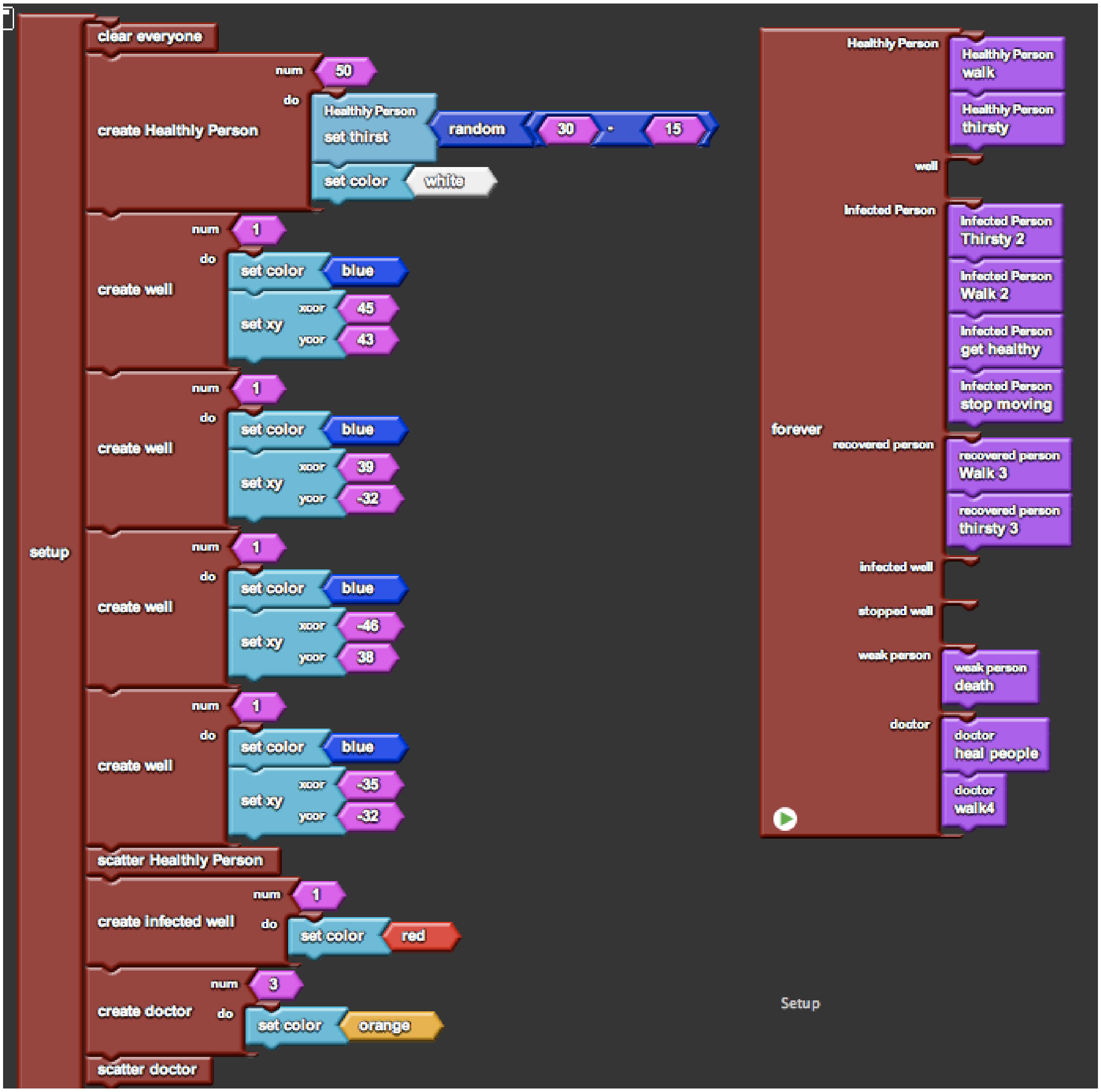
[5] "Cholera", *World Health Organization*, June 2010, http://www.who.int/mediacentre/factsheets/fs107/en/

[6] "Cholera in Haiti Introduced by UN Nepalese Troops Confirms Swedish Ambassador", *Word Press*, http://ktwop.wordpress.com/2010/11/16/cholera-in-haiti-introduced-by-un-nepalese-troops-confirms-swedish-ambassador/

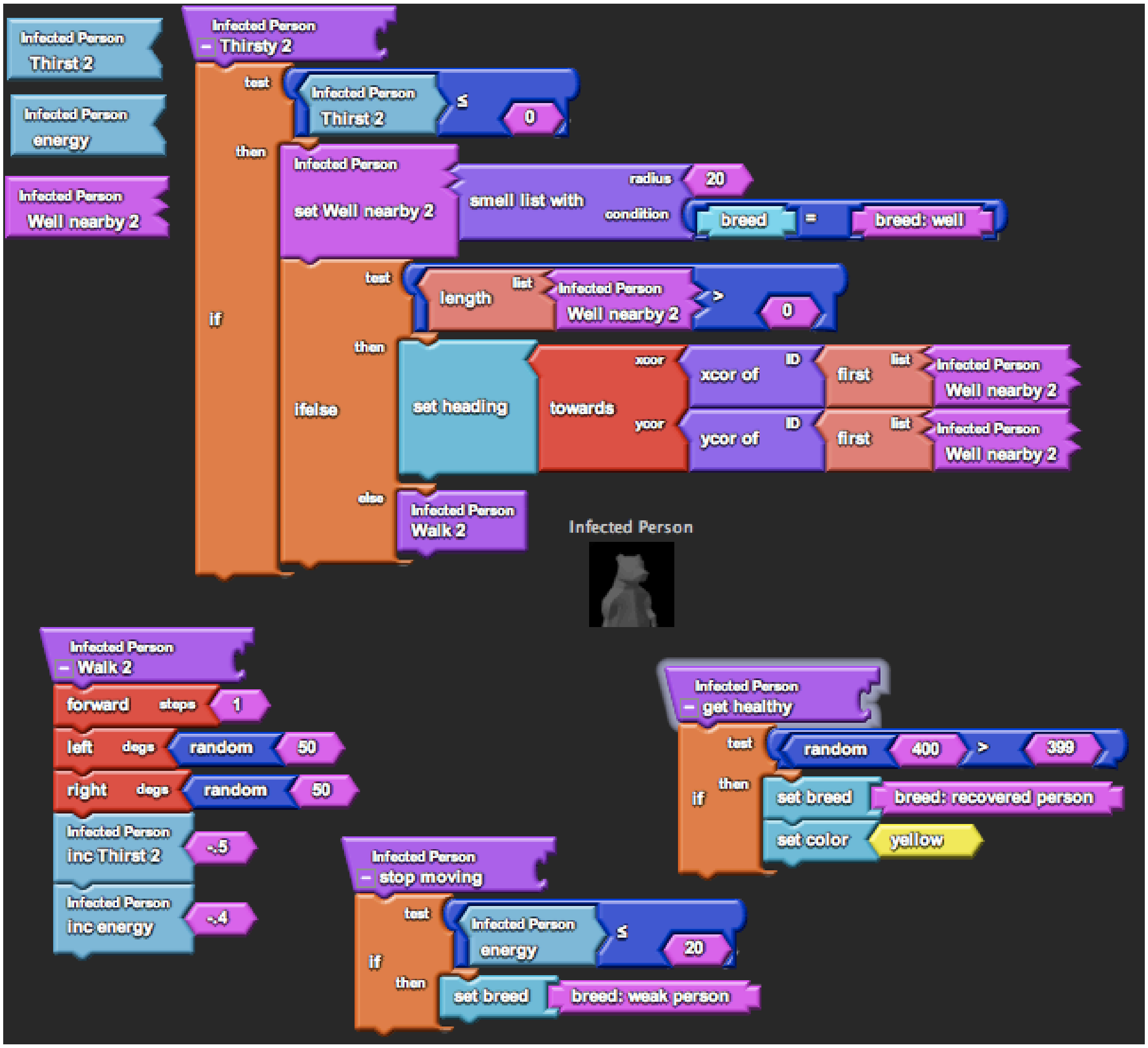
[7] "Cholera Outbreak in Haiti" *Organisation Mondiale de la Santé*, 2011, http://new.paho.org/hai/index.php?lang=en

[8] “UN Cholera Spreads from Haiti to Dominican Republic”, *Word Press*, 17, Nov. 2010, http://ktwop.wordpress.com/2010/11/17/un-cholera-spreads-from-haiti-to-dominican-republic/

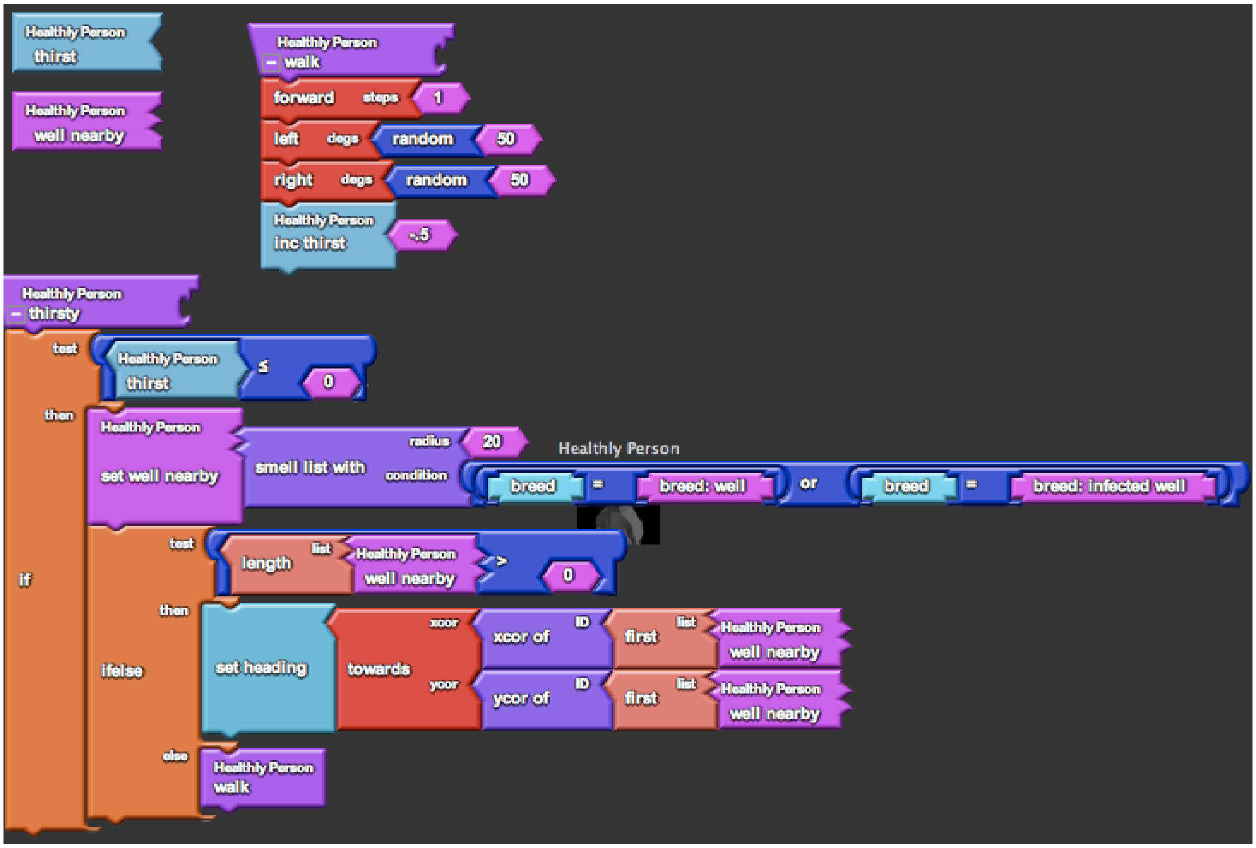
Code



This picture shows the setup for our model. It is creating the agents and wells. It also shows the forever block, running all the procedures.

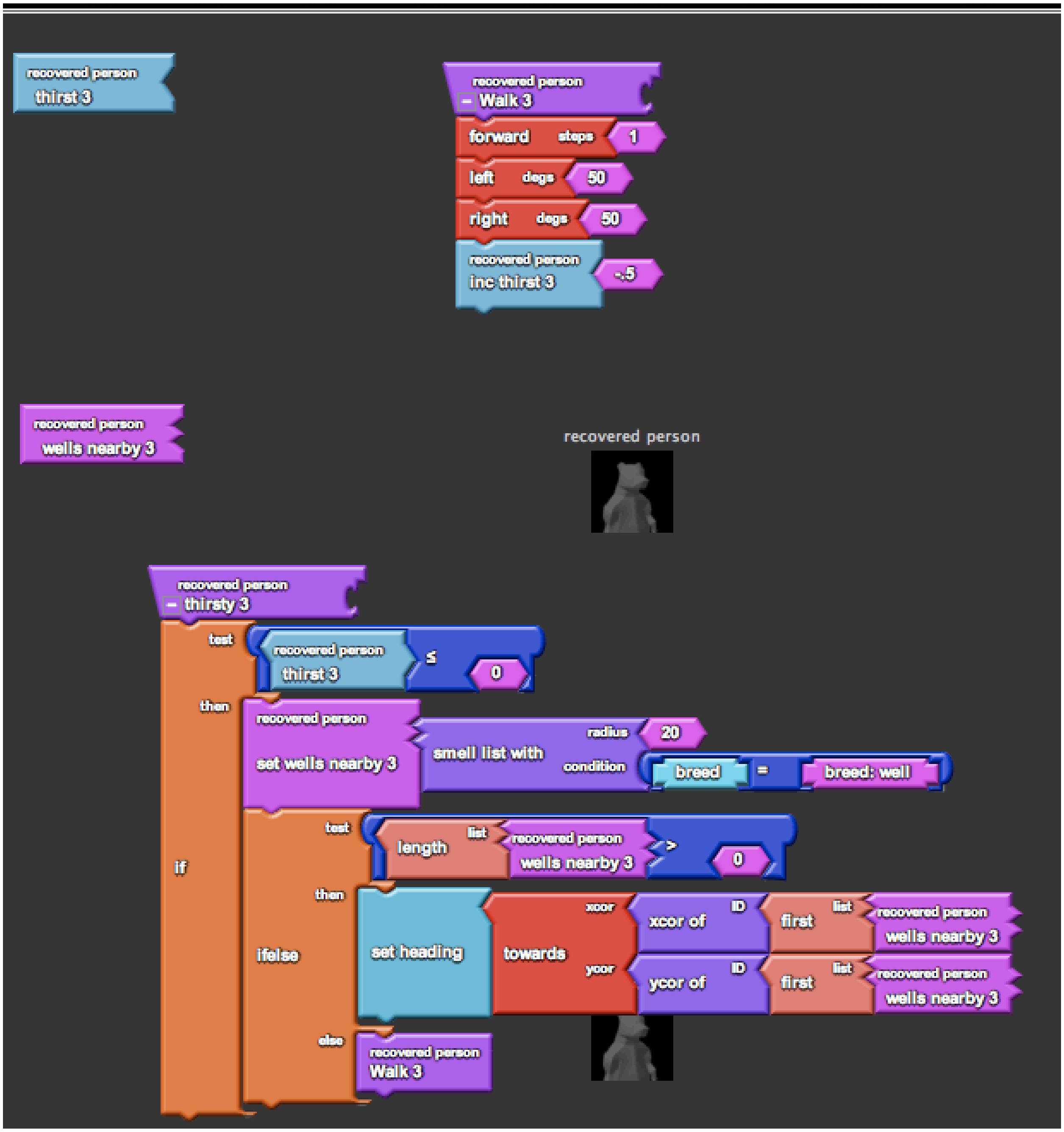


This picture shows the code for infected agents. There are the agent's variables, the thirst procedure for getting water, the procedure for walking, the procedure for getting to sick to walk, and the procedure to recover.

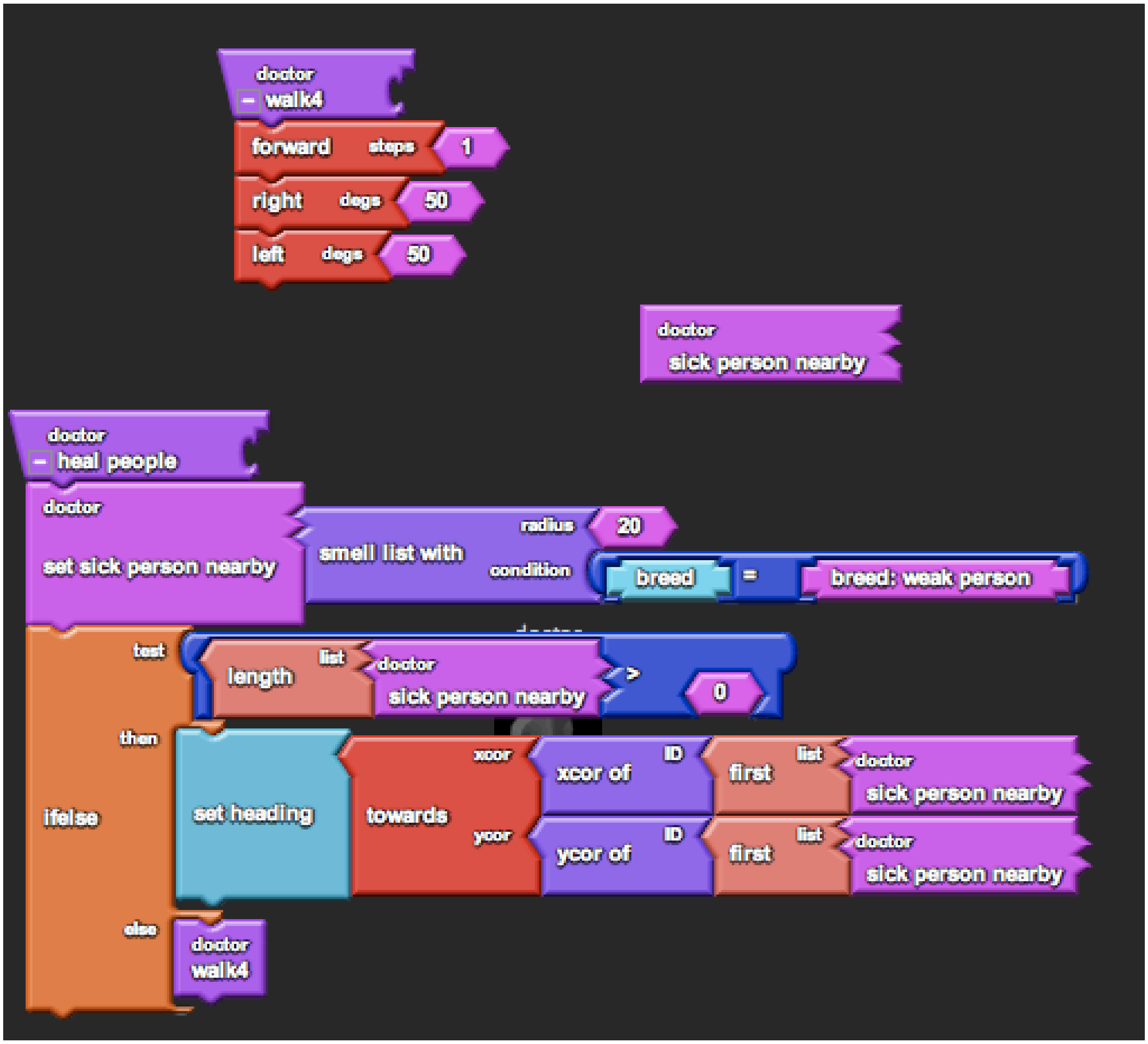


This is the code for the healthy agents. There are their variables, the procedure for walking, and the procedure to get water.

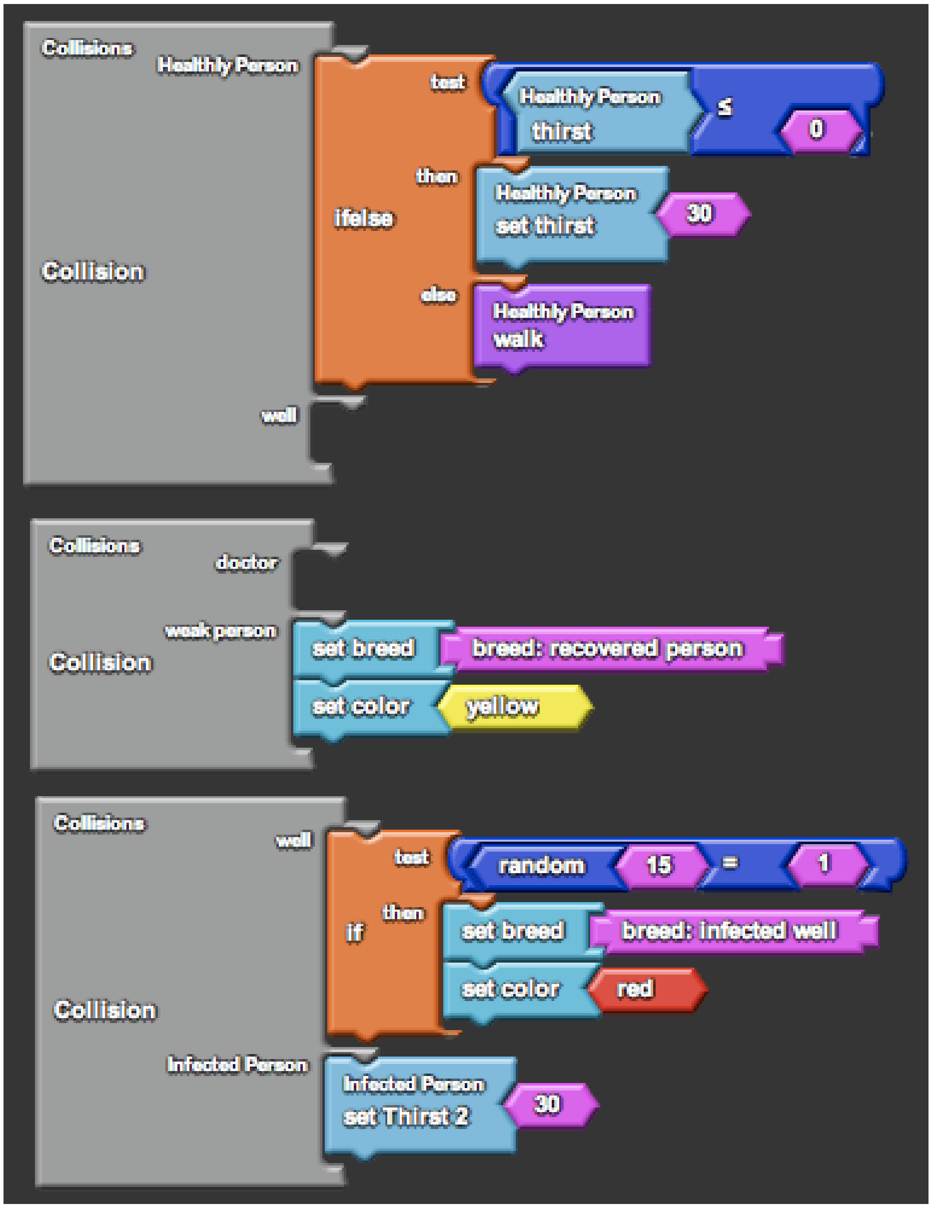
This code is for weak agents who are too sick to move. The procedure tells them to die.



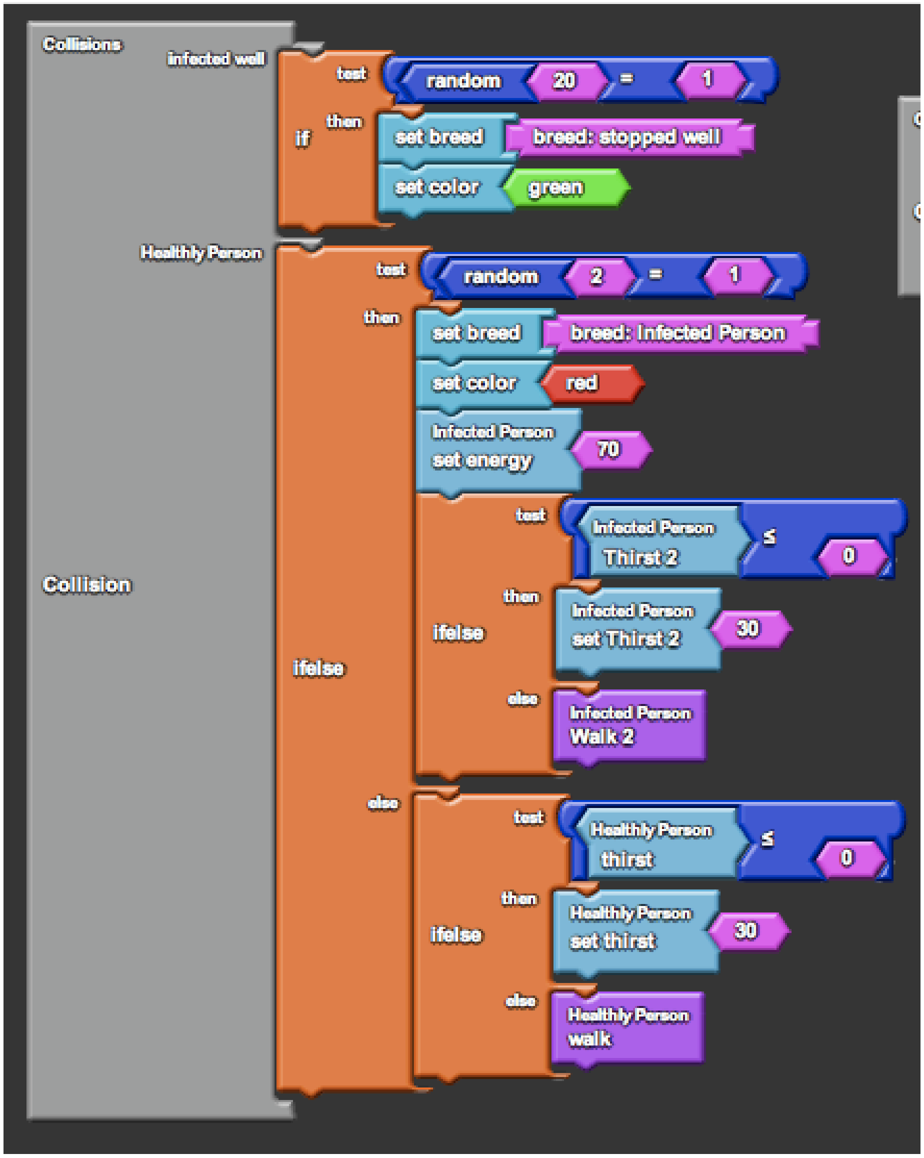
This code is for recovered agents. There are their variables, the procedure to walk, and the thirst procedure to get water.



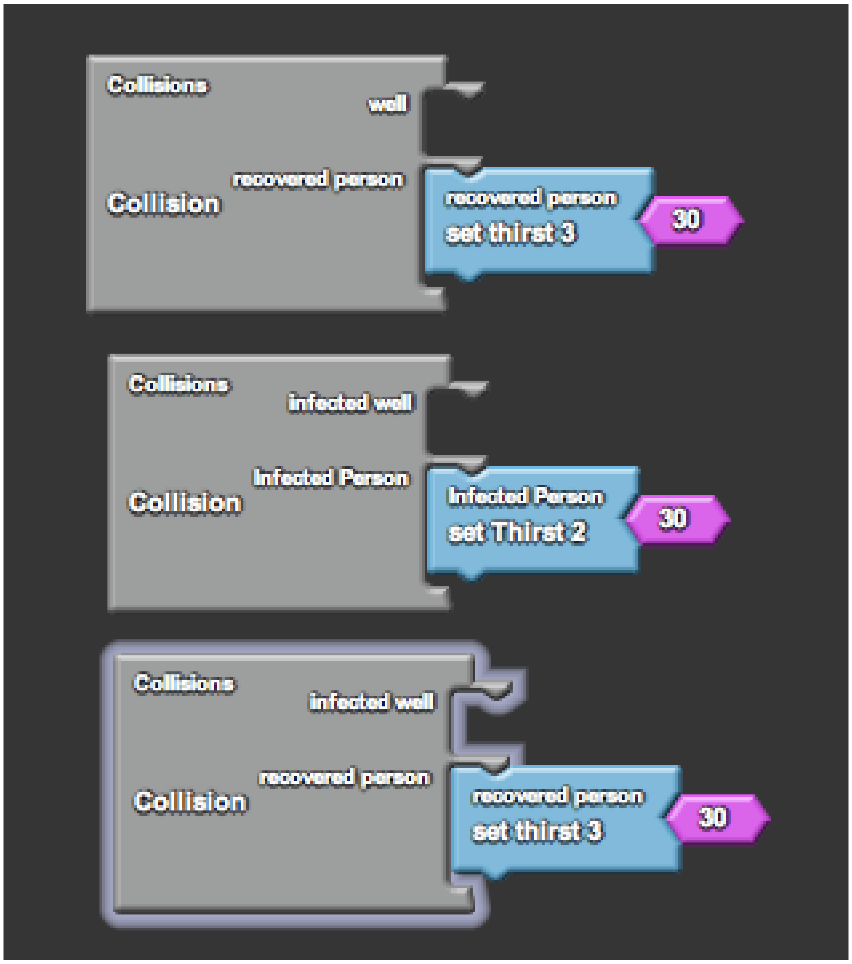
This code is for the doctor. There is a sick person shared number, a procedure to walk, and a procedure to find and heal sick people.



These are a section of the collision blocks. The first one is for a collision between a healthy agent and a well, where the healthy person sets their thirst variable to 30. The second block is a collision between a doctor and a weak agent where the weak agent recovers. The third block is for a collision between a well and an infected agent where the infected agent drinks water and the well has a chance of being infected.



This code is a collision block between an healthy persona and an infected well where the healthy agent has a chance of getting infected.



These collision blocks are collision between agents and wells where the agents are drinking (setting their thirst variable to 30).