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ODD Description

1. **Purpose and Patterns:**
   The model was made to investigate the effectiveness of prevention methods for the risk of spreading a viral infection in an outbreak, such as COVID-19, in a population, specifically vaccine doses and quarantining. The model is used to compare the risk reduction rates of both methods and even combine the two methods with the ability to set when quarantining and getting vaccines will start, how long people have to wait in between vaccine doses, how long people stay infected or have immunity for, and the risk reduction rates of vaccine doses. Stochastic elements of the model include risk of infection, recovery, when people get the vaccine, whether people are considerate to quarantine, and whether people are antivax.

2. **Entities, State Variables, and Scales:**
   The model has two kinds of entities: humans and the landscape. Each human has an x and y position at all times. Humans can be in one of three states; susceptible (able to get infected), infected, or immune (unable to get infected for a period of time). Humans have integer variables 'infection-days', 'immunity-days', and 'waiting-days' representing how long since their last infection, last recovery, and last vaccine dose respectively. They also have other variables indicating whether they have gotten their first dose, their second dose, whether they are considerate and if they are antivax. Simulations last until the last infected person has recovered or until the max number of iterations has been reached which can be set accordingly. Population size, infection and recovery rates, infection and immunity period lengths, waiting periods between vaccine doses, and when quarantining and getting vaccines start are all the other environmental variables. Each tick is considered one day. The space in the model is represented continuously over a 31x31 the landscape that wraps around both horizontally and vertically.

3. **Process Overview and Scheduling:**
   The model includes five processes that happen every tick in the following order: **i)** The movement of humans - every tick, humans move one unit in a random direction from 360 degrees. **ii)** Checking on immune humans losing their immunity and going back to a susceptible state after their immunity periods are over. **iii)** Checking on non-infected humans on whether they are getting a vaccine - it keeps track of each humans' first and second doses, with there being a vaccine delay period for how long it takes for the vaccine to be available from the start of the simulation and a vaccine interval requirement for how long humans must wait before getting their second dose. Of course, this only applies to non-antivax humans. **iv)** The recovery of infected humans - this is decided by a combination of how long they have been infected divided by the (typical) infection period (50%) and a random percentage (50%) where if the sum is above a certain recovery threshold the person recovers and becomes immune. **v)** The spread of infection from infected humans to susceptible humans - infected humans can infect their neighbours and the probability of their susceptible neighbours contracting the infection depends on how many vaccine doses they have received {0,1,2}. Also, infected people can only infect others if they are not 'considerate' enough to quarantine, which can only happen after a "quarantine delay" as populations won't know that they need to quarantine when it all first starts.

4. **Design Concepts:**
   The main driving principles the model addresses are that the spread of a viral infection can be reduced by having infected people quarantine and by having people take dedicated vaccines. This can be demonstrated by observing the number of infection cases overtime after quarantines are set in populations and after vaccines for the infection are made available to the public. The model's infection behaviour is mainly based on the interactions between infected and susceptible humans and follows the understanding that infections happen by close contact transmissions from an infected person, and this is affected by things such as infected people being considerate enough to stay at home and susceptible people's immune

system from vaccines. The model assumes all 'infections' are bad and that vaccines are good in preventing risk of infection, making minimising the total number of infected people the objective. No learning is conducted.

The effects of quarantining and vaccines on infection spread cannot be observed through any single individual and cannot be confidently concluded with a few observations. This behaviour is therefore emergent on the population system. There are multiple stochastic aspects of the model when it comes to quarantining and getting vaccines as not everyone in a population would know they are infected, would be willing to quarantine even though infected, would want to get vaccinated, or are able to have speedy recoveries. Those are a few aspects included in the model, however, there are definitely many other stochastic factors that tie into this outside this model such as the effectiveness of different types of masks, the variant type of the infection the infected person has, the humidity of a location, the limited number of vaccines, the type/brand of vaccines, etc.

For ease of observation, a graphical display is used for human locations, human states according to color {susceptible: white, infected: red, immune: green}, and different icons to indicate the number of times a human has been vaccinated {0: sad face, 1: neutral face, 2: happy face}. Furthermore, plots of number of infected people, number of first doses, and number of second doses, each against time (ticks/days) are made to compare to one another.

5. **Initialisation:**
   A specified number of humans are initialised into the wrapped landscape, each at random coordinates. Each human starts as susceptible (not infected or immune) with no first or second dose. Each human's number of days infected, immune, and waiting for next dose are all initially set to 0 and are only incremented or reset to their corresponding states overtime. Two random percentages are created for each human which decide if they are considerate and if they are antivax, both following set percentage thresholds. After all humans have been initialised, one human is set to be infected.

6. **Input Data:**
   The model takes in a lot of input data; number of people to initialise, probability of infection from infected to susceptible people, a recovery threshold for an infected person, length of infection and immunity periods, max number of ticks, how many ticks from the beginning to start quarantining and have vaccine available, probability of non-antivax people getting a vaccine per tick, number of days to wait to get a second dose, probabilities of people being considerate and antivax, and infection reduction multipliers for the first and second dose.

7. **Submodels:**
   From section 3, process i) is relatively straight forward as described above. In process ii) an immune human's number of immune days are compared to the inputted immunity period and if it is larger than or equal to the period the human becomes susceptible again and is no longer immune.

   For process iii), a random percentage [0.0, 1.0] is drawn and if it is less than or equal to the inputted probability of getting a vaccine the human gets their next vaccination. For second doses the process makes sure the inputted required number of days has passed since their first dose. It is also here where the previously mentioned icons are changed accordingly to when humans get their first and second doses to neutral faces and happy faces.

   In process iv), the deciding equation is calculated as follows:

   $1/2$ (number of days infected / infection period) + $1/2$ (random percentage) > recovery threshold

   So the longer a person is infected for the more likely they are to recover.

   For process v), a random percentage is drawn and depending on how many doses the susceptible human has had {0,1,2} if it is less than {probability of infection, probability of infection * first dose reduction, probability of infection * second dose reduction} respectively the susceptible human becomes infected.