I. Introduction:

For assignment four, the wicked problem that Uyen and I chose to solve is the Zika virus problem.

II. How the Zika virus qualifies as a wicked problem:

Containing the Zika virus qualifies as being a wicked problem as it meets the following criteria outlined by Rittel and Weber in their paper: *Dilemmas in a General Theory of Planning:*

1) There is no definitive formulation of the problem that the Zika virus presents. On the surface, it is a disease that needs to be contained, but there are also social, economic, and political factors that complicate the surface issue. Additionally, while it may be easy to define a goal: eradication of the virus; it is difficult to formulate a strategy that would be able to accomplish this goal and it is impossible to tell whether or not the goal has been achieved, or if it simply seems as if it has been achieved due to imperfect information about the domain (earth / the human and mosquito populations specifically).

2) Given the fact that there’s no actual test for whether Zika has been completely eradicated from the planet, or if it merely seems that way, there cannot be a stopping rule, but rather merely a ‘waiting’ rule that puts some strategy on hiatus until disease reemergence.

3) There are better solutions and worse solutions to dealing with the Zika virus problem, but there is no binary definition of True-False when it comes to wicked problems.

4) Since it is impossible to test every human and every mosquito for the presence of Zika, there is no feasible test for whether or not the goal has actually been accomplished.

5) In order to tell how effective a given strategy really is, it is necessary to enact that strategy on a real population with the Zika virus; this means that there will be no opportunity to start-over with any given population. There is no reversing the consequences of a failed strategy in disease containment. The problem will only get worse.

6) The set of Zika containments strategies are not enumerable and the strategies that are describable are themselves extremely subjective and mutable. An example of this would be running an “awareness campaign” to inform the public of the existence of the disease and the ways in which they can avoid contracting it. While this is a simple statement on the surface, how this strategy is carried out is ill-defined and extremely subjective. Furthermore, there can be no true estimate of how an awareness campaign will affect the incidence rate until after a campaign has been carried out and the incidence rate measured.

7) Containing the Zika virus may fit into the broader category of disease containment, but the qualities that make it essentially unique are the specific disease characteristics, such as how it's transmitted, how long it lasts, the fact that 80% of the population that has it doesn't show symptoms and the symptoms themselves. These different characteristics come together and create a unique situation which makes it unamenable to the direct application of general problem solving techniques.

8) The Zika virus could be considered to be a symptom of multiple other problems: the proliferation of mosquito populations, the latent effects of modern urbanization, or the general issue of disease mutation.

9) The discrepancy representing the Zika solution could be seen as one of the proliferation of mosquitos, or the disease itself. Depending on how it is framed, the possible operators will change.

10) Being wrong means real-life consequences for women and their children with Zika virus. Allowing the disease to spread means a higher rate of pregnant woman contracting the disease and therefore a higher rate of connected birth defects. This means that those people planning the containment cannot afford to be wrong.

II. OUR PROBLEM FORMULATION PROCESS:

a) Describing a need – Zika virus is a pernicious and difficult to defeat disease; reducing or eliminating the incidence rate would be greatly beneficial to millions of people around the world in that it would alleviate human suffering as well as reduce government expenditure in dealing with the disease in the long run.

b) We captured the myriad resources available to solve this problem by reducing all of them to "funding". Funding consolidates both monetary and human resources into one variable.

c) Restriction and simplification - Given the fact that Zika is a problem worldwide, and that its proliferation adds complexity, we reduced the problem by applying our solutions to one homogenous "population". This population does not delineate between genders or the method of transmission. Further iterations of the program could do so, however the model would still be less complex than the actual problem.

Additionally, we reduced the problem's complexity by consolidating all of the dimensions of different campaigns and strategies into single operators with an estimated over-all effect.

d) Design a state representation – Our State class has data for the following: Population size, number of infected people, incidence-rate, funds available, and the current iteration (each iteration is analogous to one calendar-quarter)

e) Design a set of operators – Our operators are designed to reduce the incidence-rate. They are meant to mirror the following strategies: mosquito-awareness-campaign, sexual-transmission-awareness-campaign, mosquito-population-reduction, clinical-isolation-and-treatment. Each operator has a specified cost. The cost is an estimation of the money and person-power required for the given strategy. For the clinical-treatment operator, cost is a function of the number of ill-people in the population; for the rest it is a hard coded estimation.

f) Listing constraints and desiderata – Funding was the primary constraint, additionally an implicit constraint of not being able to apply multiple operators per iteration existed. Since, in the real world, strategies are usually never one-fold, we have coded in the ability for the operators to mix the four above listed strategies and for the incidence rates and cost to be reduced accordingly.

g) Specifying in code the state representation etc. *See Zika.py*

h) Specifying in code a state visualization method. *See output of Zika.py*

III. What was captured in our problem formulation:

Given the wicked nature of our problem, the specifications for formulation were not clearly outlined. This means that we had to determine the definition of the problem, the scope and perspective from which we were approaching the problem, what defined a more or less successful outcome, and the manner by which we would achieve a most-successful solution. Since Google's effort, according to Jaculine Fuller in her blog post *Providing Support to Combat Zika in Brazil and Beyond*, seemed to be towards predicting outbreaks, we chose to focus our efforts on how to contain, reduce, and mitigate the problem in some given population once it had already occurred.

Our program has the following features:

a) Each iteration represents one calendar quarter.

b) Every four calendar quarters "funds" are added to a "funds" variable.

c) Each Operator has a "funds" cost; if the funds aren't available, then the operator cannot be applied.

d) The disease incidence rate changes per the iteration modulo 4, this is analogous to seasons and aligns with the funding functionality.

We quantified the definition of a good or bad outcome by measuring the incidence rate per 100,000 people. A lower incidence rate correlates with a more successful solution, a high one means a less successful solution. We also kept track of the raw number of people projected to have the disease by multiplying the population by the incidence rate and used this to calculate the h: function, since a higher number is inversely correlated with a good-outcome.

In our program, the generation of a new state represents the coming of a new calendar quarter. This effects not only the base incidence rate of infection (as described below), but also how much money is remaining in funds. Ideally, were this program to be implemented, estimations of the funds available and the funds spent on the various Operators would be entered in to calculate the most efficient solution within the bounds of the monetary constraints; right now, estimated costs have been entered.

For our operators, we chose various containment and prevention solutions and assigned to them various levels of efficacy in reducing the incidence rate of the disease based on assertions made by the World Health Organization and the Pan American Health Organization in their *Zika Epidemiological Report.* The formula chosen for the incidence rate was as follows:

$$incidenceRate = baseRate - (baseRate * (totalReductionRate))$$

Formulating the incidence rate in this way means that efficacy of a given solution is effected by the magnitude of the base rate. The same solution applied to two different base rates will result in a proportionally equivalent reduction, though the actual rate of reduction will vary. We formulated the incidence rate in this way so that it is most effective to save the costlier but more efficacious solutions for the times during which the base infection rate is highest (Spring and Summer).

We built into our program the ability to mix different strategies and calculate the efficacy of that mix, though that functionality is turned off. Zika virus is most prevalent in regions close to the equator and especially during Spring and Summer (see the WHO and PAHO Zika Epidemiological report of 28 April, 2016) and it is for this reason, we cycled the base_incidence_rates based on which quarter the current iteration represented.

Additionally, in addition to the state-change, our program displays the Operator it used to get there, which essentially allows the user to find the 'best solution'.

IV. What we learned:

A) Uyen: This assignment helped me to look at a wicked problem in a simpler perspective. The assignment also guided me through the step-by-step process of how to break down a complex problem. I also learned to recognize the constraints, resources, what can be modeled, and how is it different from reality. I learned how to define a wicked problem, how to generate a problem formulation of it, including defining the problem and designing a state representation. I am aware that the model used in this assignment to solve the Zika problem does not simulate exactly what reality is like. However, the algorithm helps understand the key factors the affect the plan to deal with Zika disease.

This is also the first time I code and share the same file with someone else, and realize how difficult it can become. This assignment somehow helps me learn how to do coding assignment/project with other people. We are still trying to figure out the best way to do it. I wish there would be more in-class "tutorial" that helps/shares with us how to work efficiently on a coding assignment in a team.

B) Brian: This assignment taught me a great deal about what the problem formulation process looks like for real-world issues. There's a science behind it, but also a bit of an art. Coming up for "costs" for the operators was a part of that art and they ended up being proportional to the effort and money we thought they would cost *in relation to each other* rather than reflective of any real-world estimates. Additionally, this project has helped me improve in methodically proceeding through problems. When developing a solution, a problem-solver needs to think about not only the constraints on the problem, but the constraints that exist on their own time. It was especially interesting to read about Google's approach to the problem: that they were attempting to predict outbreaks before they happened. Uyen and I both had very different ideas about how the problem might look, and part of what made this project interesting was negotiating an approach to it.

This was not my first time coding in a pair, but it was my first time using github as a medium for the code, and I've never had formal instruction on how to develop a project with another person. In the future, I think if we were to increase the modularity of our program and assign certain program functionalities to individuals, that would increase the effectiveness of our group. Instead of trying to figure out another person's code and their thought process, we would only need to understand the input and the output of that functionality.

I believe we were pretty successful for the amount of time that we had. In the future I would want to model the problem differently and add some important variables I think would affect the outcome in the real world. Additionally, if we had a database with prior disease containment attempts and solutions, we would be able to code a more apt solution.

Finally, since this class represents my first foray into Python, it represents a continual learning experience when it comes to building solutions with the language. It's pleasingly clean and surprisingly powerful. Hopefully by the end of the course, I will be able to complete assignments like a true python programmer, rather than by pretending Python is part C part Haskell.

References:

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