Spring 5-26-2020

Mathematical Modeling of COVID-19 and the Potential Effects on Eastern Washington University Student Population

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Statement of Purpose

- The purpose of the proposed project is to predict the outcome of COVID-19 on Eastern Washington's Fall 2020 student population.
- We will be using the EWU population to examine if reopening campus for fall 2020 is safe and study the potential effects.

Background and Significance

- The World Health Organization announced the official name of COVID-19 on February 11, 2020 to identify the novel coronavirus outbreak.
- This virus has spread rapidly since it was identified in Wuhan, China and has a large spectrum of clinical outcomes and severity.
- This is due in part to air and train traffic to Wuhan and it is estimated that more than 800 infected individuals traveled internationally to spread the disease to other countries with Thailand and Japan being the hardest hit (Brüssow 2020).
- The disease presents itself with dominant symptoms of fever and cough with all other symptoms being uncommon (Guan 2020).
- The virus primarily spreads from person to person through contact with the mucous membranes of the eye and nose as well as saliva.
- Incubation periods tend to be around 5-6 days, but evidence shows that it can be up to as long as two weeks (Baghizadeh 2020).
- There is no evidence-based treatment or cure for the virus, however the production of a vaccine against the COVID-19 outbreak is the primary goal for chronic treatment in the population.
- As of April 6th, 2020, the state of Washington has extended a ban on all in person activities
- Current research indicates that in Eastern Washington, the R0 value is estimated to be between 0.89 and 1.26 with a best estimate of 1.07 as of May 4th's calculations.
- The reproductive numbers in Eastern and Western Washington have significantly decreased from the rough initial estimate of 3.
- Physical distancing is our cheapest and main tool from the reduction in COVID-19 spread and it is estimated that in Eastern Washington it is likely that we have a prevalence between 0.1% and 0.6% with a best estimate on 0.3% (Thakkar 2020).
- We wish to create a scenario in which students could return relatively safely to school.

Objectives

- This project's objective is to indicate the level of safety and risk associated with the reopening of Eastern Washington University to in-person classes.
- Firstly, we must develop an applicable set of parameters to replicate the population of EWU in order to test a likely path of spread.
- After this has been applied, recommendations regarding the efficacy of safe school opening will be given.

Procedures and Rationale

- Eastern Washington University is located in Cheney, Washington (State) with a student population of 12,326 as of Fall 2019.
- This study is based on the application Covasim which is a stochastic agent-based simulator designed to be used for COVID-19 epidemic analyses (https://covasim.idmod.org/).
- Each individual is categorized by the susceptible, exposed, infectious, and recovered/dead as per the SIR disease model.
- The model creates a simulation object with parameters and a population with demographics and comorbidities is additionally generated.
- Agents in a network are then looped in an integration where dynamic scaling, health constraints, agent updates, disease progression, importation events, applied intervention, calculated disease transmission events across the contact network, and finally the collation of outputs in results arrays (Kerr & Stuart et al. 2020).
- The progression of the disease is set at a mean incubation period of 4.6 days and individuals are categorized by asymptomatic, pre-symptomatic, mild, severe, or critical.
- Due to variability in exposure to infectious time and age severity, from the model, this is captured through a probability scale stratified by age demographic.
- A beta value of 0.0016 is generally assigned assuming an average of 20 contacts per day.
- This value represents the probability of transmission at any given contact and is also stratified by contact type such as workplaces, schools and communities
- Differences in viral loading per individual are also considered in the model
- SynthPops networks consider mixing patterns of differing contact types and their population distributions, and it is the default choice for Covaism
- The interventions available are; distancing and hygiene, testing/diagnosis and tracing.
- These interventions are put on a slider scale from 0-100 where a 0 would be absolutely none of that intervention and 100 being that intervention to its fullest capability (Kerr & Stuart et al. 2020).

Procedures and Rationale (cont.)

- For effective reproductive number we use the equation (Bakir, 2016):
$$T = \frac{w \log(2)}{n_i(t)/n_i(t-w)}$$
- T is doubling with W being window length and n(t) being cumulative infections. For the SIR model we use the equation (Barratt & Kirwan, 2010):
$$R_{eff} = R_0 S/N$$
- Both equations are important because they're used through the covaism model for calculations on the population
- R0 is the reproductive number, S is susceptible, and N is the total population
- Seeing as the model is stochastic, multiple trials are run to account for variability among different simulations.
- We propose the use of a control simulation with no interventions along with simulations using the lower, average, and upper estimates of prevalence.
- Our population will be assumed to be its own community, separate from the rest of the population due to the limitations of the model and the time will be set to 72 days as is the length of Fall quarter of 2020.
- The model is limited in scope due to a reduced range of beta values between 0 and 0.2 and as such we will use 0.01, 0.1, 1.5, 0.2 as our experimental conditions
- Our control will be defined as having 0% intervention on all four general parameters with variation among infectiousness (beta) while our initial infections will be set to one to represent a hypothetical initial infection coming into the EWU community.
- Each scenario will be tested 5 times each to account for variability and comparisons of statistically significant differences in treatment will be assessed.

Conclusions

- Social distancing parameters would be the most impactful intervention.
- We understand that COVID-19 spreads through respiratory droplets, coming in close contact with people can increase the spread of this virus.
- Social distancing parameters are essential to limiting possibly exposed people from healthy people, thus keeping the infectious rate low.
- Since the social distancing recommendations and laws, we saw a major decline in new COVID-19 cases (Brüssow 2020).
- From this, we can make the educated conclusion that if we continue social distancing at our current rate, then the rate of infection will decrease.

Figures

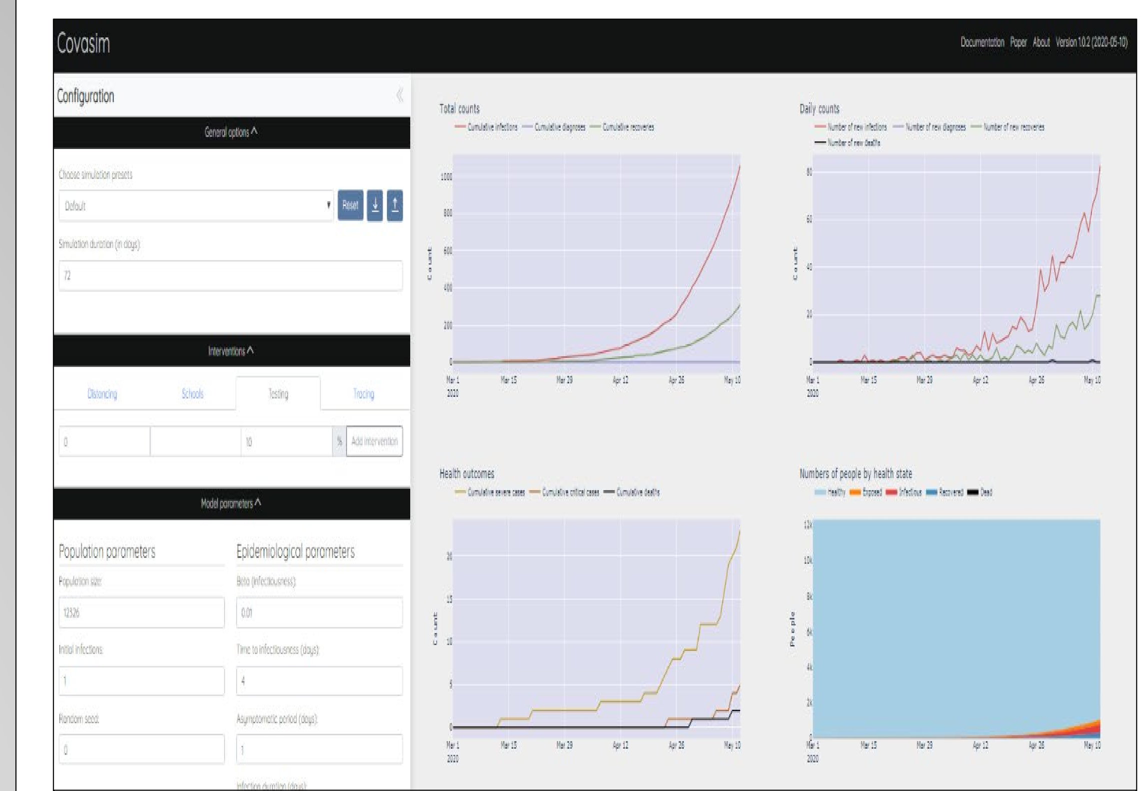

Figure 1: An example of even at a low infectious rate, no intervention will likely lead to a localized outbreak on campus

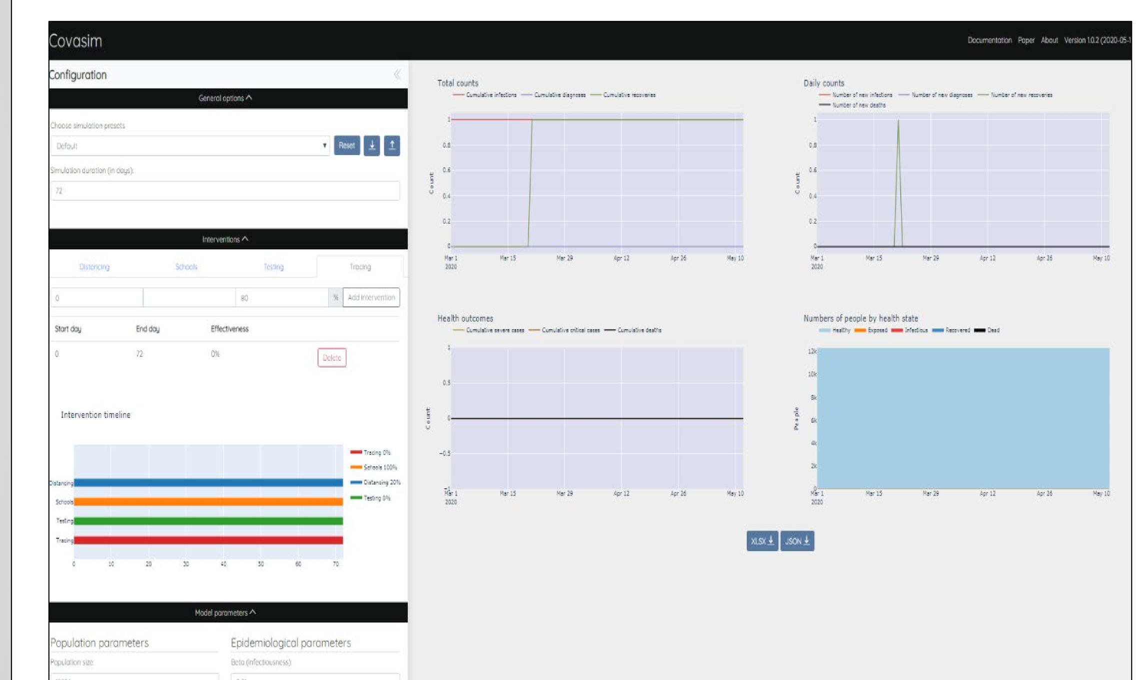

Figure 2: A successful intervention EWU parameter set that does not allow for an outbreak

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