Project 3 -

Simulation that Shows Alternative to the Stagnant Funding for Sex-Ed in America

Abstract:

Chlamydia affects 2 million people nationwide. An SIR model analyzes and runs a simulation to see if more federal funding can reduce the number of people infected with Chlamydia. A modified version of the SIR model is used, with three differential equations and three parameters. Results showed that $100 million additional federal funding would be required to manage Chlamydia.

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Objective:

Chlamydia is one of the most common sexually transmitted infections (STI) in the world. The number of infections have been steadily rising since the 1980's. In 2019 alone, 1.8 million people in the United States were infected (CDC). Up until 2010, there was no federal funding for preventative STD care. In 2010, the Federal Government established the Personal Responsibility Education Program (PREP) as part of President Obama's health care reforms. The primary goal is to promote education on abstinence and contraception to prevent unplanned and/or teenage pregnancies and STIs. PREP, starting in 2011, has an annual budget of 75 million (Family & Youth Services Bureau). The funding has not increased since its founding. STIs are costly to the nation's economy, with nearly 68 millions infections, STIs cost us approximately 16 billion dollars per year (CDC). This led to the question of whether an increase in its budget would make a difference to chlamydia infection rates and cases. This information can be useful to healthcare workers, politicians, school administrators and pharmaceutical companies. All of these observations lead us to the project question: can more federal funding for preventative STI measures reduce the percentage of the population infected with chlamydia?

Methodology:

Looking at the relationship between chlamydia cases and sexual health funding in the US led to two parts of the project statement that used a computer simulation:

i) The percentage of the population infected with chlamydia over time.

ii) Effect of federal funding on it.

It required three separate but connected populations: one that was Susceptible, one that was Infected, while a third that was being Treated. There was a circular relationship, where Susceptible went to Infected, Infected went to Treated, while Treated went back to Susceptible (as there is no vaccination or immunity). This Deterministic model had three differential equations, which required three parameters, beta, gamma, and theta, where beta = contact rate, gamma = medicated rate, and theta = treated rate. The model was:

Infected = system.beta *i *s, Medicated = system.gamma *i, Treated = system.theta*m

The Kermack-McKendrick model was used for the first part of the project statement, changing the R in SIR to M (to mean Medicated), changing it from a linear to a circular model (which research showed better reflected the life cycle of chlamydia in patients), and adding a third parameter called theta for treatment rate. As one day was used as a step in the model, and the number of days for treatment was 7 days (WDHS), gamma equalled 1/7. Similar reasoning led to theta equaling 1/7 (CDC). As research lacked over the number of days it took to get infected, a range of beta values was identified to run through the simulation, to find a beta value that better reflected reality.

The US population was treated as one mass and uniformly distributed, which when expressed in millions was around 310. As 50% men and 75% women do not show symptoms (WebMD), and as there were almost 2 million cases in 2019, calculations led to 1 million male w/symptoms, totaling 2 million (including no symptoms,) & 1 million female w/ symptoms, totaling 4 million (including no symptoms), leading to 6 as the assumed total. Medicated were arbitrarily assigned as 0.1

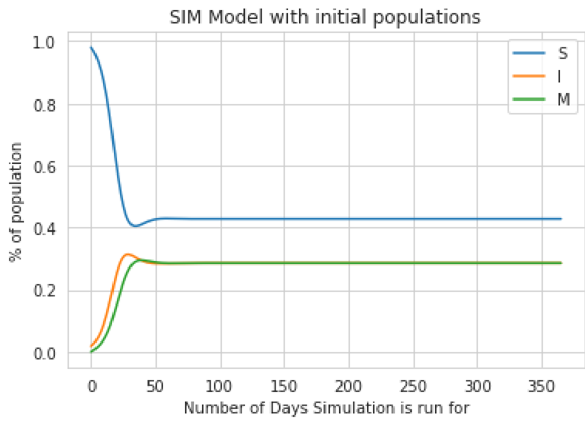
After plotting Chlamydia cases data from CDC, the slope of the line of best fit that modeled the cases from 1984 to 2010 was 16, while the slope from 2011 to 2019 was 10. It was assumed that was because the first section involved zero federal funding while the second section involved a section of $75 million federal funding that could be used for preventive STI education. This funding by the federal government was chosen as the intervention that would be used in the simulation to reduce infection percentages.

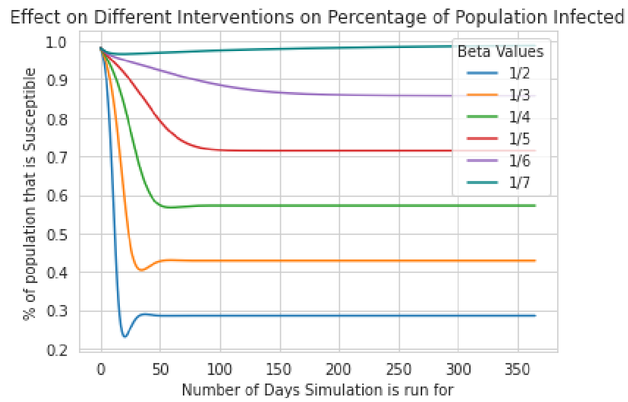
The metric of interest was the percentage of the population that was infected, as the proposed intervention of increasing funding for PREP in increments of $25 million was introduced. The project statement question would be answered by showing the effect that funding had on the percentage of the population that is infected over time. The assumption related to the intervention was that $25 million out of PREP's total budget of $75 million was spent on preventative sti measures. The second assumption related to the intervention was that the addition of each $25 million decreased the contact rate by 1, while eliminating the funding in entirety increased the contact rate by 1 (which was supported by figures from 1984-2010 when there was no federal funding and the rate of growth of cases was higher). Beta values' assumed relationship with funding is represented by the following:

½ = no funding, ⅓ = 75 million, ¼ = 100 million, ⅕ = 125 million, ⅙ = 150 million, 1/7 = 175 million

In order to make the model more representative of real life, the data point for 2020, which was affected by COVID, was removed. In addition, only ⅓ of PREP's funding was assumed to have been used for preventative STI measures. The data is mostly reliable as it came from federal and state government sources.

Results:





The beta value of ⅓ leads to a max of 30% of the population being infected at one particular time. As per model, 60% of the total population is infected with chlamydia over time. Eliminating funding led to 75% of the population being infected, each increase of $25 million reduced the percentage of infections to: 45%, 30%, 15%, and 2% respectively. This showed $175 million would be needed (meaning an increase of $100 million on the current federal funding exclusively for STI prevention) to be able to keep chlamydia infections at a low rate. With the starting populations, it took 50 days for the populations to stabilize. When funding was removed, it took 33 days. With an increase of $100 million it took 200 days. This means that the increase in funding not only reduced the percentage of population that were infected, but also spread the infections over a larger period of time.

Analysis

Chlamydia was focused because it is one of the most common STI and the quality of information available would be richer based on its commonness. Introduction of PREP in 2011 brought down chlamydia infection rates significantly. It was expected that an increase in funding for preventative STI measures would bring down the infection rates proportionally.

It was assumed that there is unlimited budget available, part of which can be allocated towards sex ed. It was assumed a person would receive medication within seven days of being diagnosed. This is often untrue in real life. Many people live with chlamydia without knowing they are infected and do not receive the treatment they need. If there was a way to accurately represent how long it takes for a person to be treated, the model would be more representative of reality. 310 million people were assumed to be susceptible, which is the population of the United States. 6 million people were assumed to be infected, which was chosen based on both real world data and logic. In addition, 0.1 million were randomly chosen as medicated due to the unavailability of reliable data, which represented a possible source of flaw in the model. The data for funding is based on STDs as a whole. Though chlamydia is obviously affected by the funding, it would be helpful if the breakdown of the funds was known, as it would have shown the specific amount that went to chlamydia prevention. Based on results, Federal funding does help prevent Chlamydia infections. As shown in the graph, an increase in Federal Funding leads to a decrease in STI's cases. This information would be extremely helpful to multiple people, especially those in the healthcare system. It is worthwhile to invest $175 million into prevention as $16 billion are spent nationwide to deal with the aftereffects of STI's.

The assumption related to the intervention that was made was that $25 million out of PREP's total budget of $75 million was spent on preventative STI measures. This was a logical assumption based on all the other activities PREP funds. A second logical assumption regarding intervention was that for each additional $25 million it will decrease the contact rate by 1 day, while eliminating the funding increased the contact rate by 1 day. And while Chlamydia cases were only focused, it was assumed that any funding on preventive STI measures had an overall general effect on other STI's infection rates too.

Other interventions, such as by clinics and non-profit organizations, were not taken into account. These factors could affect STI rates too. In addition the death rate of Chlamydia infected people was also not taken into account. While it is good to know about the infection and medication rate of Chlamydia, it is also vital to know how many people each year are being harmed from the disease permanently. Not to mention, it is also vital to know how many newborns are affected by Chlamydia.

Our model does not take into account reckless human behavior and it is unlikely that in the real world the numbers would actually reach that low of a threshold. Furthermore, Chlamydia infection rates were distributed equally throughout the country in this model. This was done to simplify our simulation. The results would look very different if it included an accurate representation of the state rates as the rates in every state vary, with some extremely high rates and others low. If the funding would be distributed equally as well it would not be able to help the places that must receive extra care. Therefore state rates must be taken into account.

Overall, one of our biggest deficiencies is our lack of definite knowledge. Much of our data is built on logical assumptions. Though it is assumed to be accurate, the finding of accurate data may pull the entire model apart if it does not match our assumptions. Some of our logical choices include, the percentage of PREP's funding towards STI's, the proportion of contact rate in regards to federal funding, and infection rate. It could improve if there was more research, capability, and humanpower to work on the model's use of details and accuracy.

The model appears decent as different inputs were tested, which led to expected outputs. The data used is culled from reliable sources. Furthermore, almost all of our assumptions are logical. The model is precise as well, it outputs a specific number. In addition, a range of values for beta was tested, which made it robust to a degree. The model is generally realistic since it can be applied to other diseases as well, together with other interventions. It is very fruitful as it provides strong support for increasing federal spending on health by a specific amount.

Conclusion:

If the federal government wants the percentage of population infected with STIs, like chlamydia, to decrease, then PREP has to be expanded. This provides support for increasing spending on public health by the federal government by showing benefits. A future modeler could further tweak the parameters. In this model, two (gamma & theta) are fixed for 7 days and only beta's range of values is tested. Testing a range for gamma and theta would improve the model. Simulation could also be run over state, local levels, and/or college populations, as the parameters used would be more realistic and research would be more available. There are also two other interventions that can be used (in combination or isolation): i) the number of sti clinics per 100,000s of the population, and ii) spending on tv, radio, social media, search engine marketing, and emails regarding preventive sti measures.

Links consulted:

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