# Epidemiology model of Covid-19

New Mexico

Supercomputing Challenge

Final Report

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**Executive Summary**

COVID-19 has taken a lot of things away from us, from family members to jobs and opportunities. My goal is to find out which type of lockdown would help slow the spread of COVID-19 within Native American communities such as my own, the Pueblo of Isleta, and modeling it in NetLogo. I started out by researching how Native American tribes have dealt with the virus and the effects of their decisions. Then how effective every type of mask is combating COVID-19. After my research, I created an epidemiology model of the Pueblo of Isleta and emulate the data I found to see how effective each lockdown is. I started by creating a simple epidemiologic model and started adding in masks and social distancing, until I created a good representation of the Pueblo of Isleta that implements the executive orders that the other tribes have used. I gave the program five variables starting with the percentage of people that start out with COVID, the number of people, the percentage of people that got the vaccine, the enforcement that determines who follows the rules, and if a lockdown is active. I ran every lockdown three times each with eight, nine, and ten percent infected, zero, five, and ten percent vaccinated, and the enforcement at fifty, seventy-five, and one-hundred. After I conducted the experiments, I came to the conclusion that the most effective lockdown is the thirty-two-hour lockdown and the least effective is having no lockdown.

**Introduction**

2020 was a crazy year, it was the start of a new decade and we start off this year with quarantine because of the virus called COVID-19. COVID-19 has taken a lot of things away from all of us from family members who contracted the virus or those who got laid off from their jobs, it's been a struggle for all of us. One of the ways of slowing the spread of the virus until we could all get vaccinated is through quarantining ourselves, keeping our distance from each other, and wearing face masks when we are out in public.

My project looks at what can be done at the community-level. Specifically, looking at the Pueblo of Isleta community. How effective these different safety measures put in place by the government and by other tribes are in slowing the spread? My solution to this question was researching how the virus spread and what other tribes have done to slow the spread. With that information we will replicate that within an epidemiologic model.

I worked on the model by using sample epidemiological models in NetLogo and using it to best replicate the disease progression. I received my data from the CDC and from tribal communities like the Navajo Nation to show how their Covid restrictions have affected their infection rates. I used the data and compared them to determine what factors effected a different outcome from the other tribes so that I could implement it within the program.

I am creating this program to help find a solution to this pandemic in my community to save our traditions. Just like every other tribal community our traditions are dying with our elders and this could be the end of our way of life if we cannot find a way to limit the spread of COVID-19.

**Method**

The goal of this project is to create an epidemiological model of the spread of COVID-19 with the Pueblo of Isleta and how different executive orders affect the spread. We first started by conducting research into COVID-19 by how it spreads, the death rates in different age and race, and how long it lasts within our systems. [5] COVID-19 spreads through the air in moisture exhaled and [7] could last up to three hours in the air under experimental conditions and 30 minutes in the real-world. [6] From Octobers update from nmhealth.org shows the percentage of deaths for Native Americans were at 13% for people between age 18 and 44, 33% were between age 45 and 64, 21% were between 65 and 74, and 33% were 75 and older. [10] COVID-19 last typically prominently 14 days to go through one's system.

Then, we looked at how effective each of the masks are in ceasing the spread of moisture particles from someone that is infected and from inhaling those moisture particles. [10] USA Today looked how efficient each of the masks were from two different studies and found out the best mask was the N95 and worst masks were the Neck gaiter. I had help from someone who works in the community and comes in contact with many people from the community who took data on the availability of masks within the community. The data was used to emulate real life by showing how many people in the model will have a certain mask. I then input the data in a chart in Microsoft word and used to create an equation (((1.25 * mask number ^ 3 - 14.774 * mask number ^ 2 + 60.357 * mask number + 1.2381) < random 100)) to show how effective the mask is in preventing someone from contracting COVID-19.

Then, I looked into what other tribal communities have done to slow their spread of COVID. Each tribe that I had looked into had similar COVID treads throughout the pandemic, but enforced different executive orders. I looked into why some tribes did better than others by determining what factor determined the outcome. For example, for a while the Navajo Nation was slowing their spread and had low COVID numbers while other tribes doing the same type of lockdown weren't getting similar results. I looked into what they were doing differently and I found that the Navajo Nation had stricter enforcement than other tribes. I then added these factors into the program as I've found them.

Once the program was created, I used behavior space to run each trial three times. I experimented with each lockdown (57-hour, 32 hours, and no lockdown) with enforcement at 100%, 75%, 50%, and 0%, with people vaccinated at 10%, 5%, and 0%, with 8%, 9%, and 10% infected, and with 900 people. Then I sort the data in excel and determined which lockdown was the most effective from the overall average.

**Code**

```
ifelse (rebellion < enforcement)
[
  ifelse (safety-protocol = "lockdown32")
  [
    home32
  ]
  [
    ifelse (safety-protocol = "lockdown57")
    [
      home57
    ]
    [
   if(safety-protocol = "normal")
      [
        normal_month
      ]
    ]
  ]
]
[
covidparticales
walk
becomesick
if (days = tomorrow)
  [
    diewithcovid
    setup-tomorrow
  ]
]
set days (ticks / 24)          ;;sets up every
```

This is how the program works. It first asks what their rebellion level is and if it's greater than the enforcement level then the turtles will continue their normal life without following the rules. Their rebellion is assigned to them at a random level between 0 and 99 . If their rebellion is less than the enforcement then they will have to follow the lockdowns during the weekend. The rebellion also determines if they follow the social distancing rules. If there is no lockdown then no one follows the social distancing and once a month some of the turtles go to the plaza to represent the dances. After every turtle has moved an hour passes and this determines the day that it is and will determine what events will happen.

## Results

### 8 percent starting infected

| Safety-protocol | Enforcement (%) | Vaccinated (%) | deaths | days |
|---|---|---|---|---|
| 32 hour lockdown | 75 | 10 | 2 | 27 |
| 32 hour lockdown | 100 | 10 | 1 | 29 |
| 32 hour lockdown | 75 | 0 | 2 | 32 |
| 32 hour lockdown | 50 | 10 | 2 | 34 |
| 32 hour lockdown | 100 | 5 | 3 | 34 |
| 32 hour lockdown | 50 | 5 | 1 | 35 |
| 32 hour lockdown | 75 | 5 | 1 | 38 |
| 57 hour lockdown | 75 | 5 | 1 | 41 |
| 57 hour lockdown | 100 | 5 | 1 | 41 |
| 57 hour lockdown | 100 | 10 | 2 | 41 |
| 57 hour lockdown | 75 | 10 | 2 | 41 |
| 57 hour lockdown | 50 | 10 | 3 | 41 |
| 57 hour lockdown | 75 | 0 | 2 | 43 |
| 57 hour lockdown | 100 | 0 | 1 | 44 |
| 57 hour lockdown | 50 | 0 | 5 | 44 |
| 57 hour lockdown | 50 | 5 | 5 | 45 |
| 32 hour lockdown | 100 | 0 | 2 | 55 |
| 32 hour lockdown | 50 | 0 | 4 | 56 |
| Normal month | 0 | 0 | 869 | 5833 |
| Normal month | 0 | 5 | 837 | 7128 |
| Normal month | 0 | 10 | 794 | 9103 |

### 9 percent starting infected

| Safety-protocol | Enforcement (%) | Vaccinated (%) | deaths | days |
|---|---|---|---|---|
| 32 hour lockdown | 75 | 10 | 1 | 28 |
| 32 hour lockdown | 100 | 10 | 2 | 31 |
| 32 hour lockdown | 50 | 10 | 1 | 33 |
| 32 hour lockdown | 75 | 5 | 1 | 33 |
| 32 hour lockdown | 100 | 5 | 1 | 34 |
| 32 hour lockdown | 50 | 5 | 2 | 36 |
| 32 hour lockdown | 50 | 0 | 2 | 39 |
| 32 hour lockdown | 75 | 0 | 0 | 40 |
| 57 hour lockdown | 75 | 10 | 1 | 40 |
| 57 hour lockdown | 100 | 10 | 1 | 40 |
| 57 hour lockdown | 100 | 5 | 3 | 41 |
| 57 hour lockdown | 75 | 5 | 3 | 42 |
| 57 hour lockdown | 100 | 0 | 3 | 42 |
| 57 hour lockdown | 50 | 0 | 4 | 42 |
| 57 hour lockdown | 75 | 0 | 4 | 42 |
| 32 hour lockdown | 100 | 0 | 2 | 43 |
| 57 hour lockdown | 50 | 5 | 4 | 43 |
| 57 hour lockdown | 50 | 10 | 4 | 45 |
| Normal month | 0 | 0 | 876 | 5595 |
| Normal month | 0 | 5 | 834 | 7231 |
| Normal month | 0 | 10 | 791 | 8594 |

### 10 percent starting infected

| Safety-protocol | Enforcement (%) | Vaccinated (%) | deaths | days |
|---|---|---|---|---|
| 32 hour lockdown | 75 | 10 | 1 | 29 |
| 32 hour lockdown | 50 | 10 | 2 | 29 |
| 32 hour lockdown | 75 | 5 | 1 | 31 |
| 32 hour lockdown | 100 | 10 | 1 | 32 |
| 32 hour lockdown | 50 | 5 | 3 | 33 |
| 32 hour lockdown | 100 | 5 | 2 | 34 |
| 32 hour lockdown | 100 | 0 | 1 | 36 |
| 57 hour lockdown | 75 | 5 | 3 | 40 |
| 57 hour lockdown | 100 | 10 | 2 | 41 |
| 57 hour lockdown | 75 | 0 | 2 | 42 |
| 57 hour lockdown | 75 | 10 | 2 | 42 |
| 57 hour lockdown | 100 | 5 | 2 | 42 |
| 57 hour lockdown | 50 | 0 | 3 | 43 |
| 57 hour lockdown | 100 | 0 | 3 | 43 |
| 57 hour lockdown | 50 | 10 | 1 | 45 |
| 57 hour lockdown | 50 | 5 | 5 | 46 |
| 32 hour lockdown | 75 | 0 | 1 | 51 |
| 32 hour lockdown | 50 | 0 | 5 | 78 |
| Normal month | 0 | 0 | 872 | 5611 |
| Normal month | 0 | 5 | 833 | 7672 |
| Normal month | 0 | 10 | 794 | 8579 |

**Average**

| | **8% starting infected** | | **9% starting infected** | | **10% starting infected** | | | |
|---|---|---|---|---|---|---|---|---|
| | Average days | Average deaths | Average days | Average deaths | Average days | Average deaths | Overall Average days | Overall Average deaths |
| 32-hour Lockdown | 38 days | 2 deaths | 35 days | 1 death | 39 days | 2 deaths | 37 days | 2 deaths |
| 57-hour Lockdown | 42 days | 2 deaths | 42 days | 3 deaths | 43 days | 3 deaths | 127 days | 3 deaths |
| Normal Month | 7355 days | 833 deaths | 7140 days | 833 deaths | 7287 days | 833 deaths | 7261 days | 833 deaths |

This shows the average amount of deaths and days it would take for infection numbers get down to zero for each different lockdown. It shows the overall days and deaths it took for the infection to subside to nothing.

## Conclusion

Overall, the 32-hour lockdown was the most effective out of the other executive orders. The data indicates that it would take a little over a month for the tribe to have a total of zero COVID-19 cases with the minimal number of deaths.

The 57-hour lockdown decreased the spread of COVID-19, but at a slower rate than the 32-hour lockdown. It took a little less than a month and a half for the tribe to be COVID free and had the same or even more deaths than the 32-hour lockdown.

The normal months increased the spread of COVID-19. By looking at the data, we can see it takes about over 19 years for the tribe to become COVID free. As we look at the death count, we can see that on average 833 people die because those who survived are wearing a high-grade mask like the N-95 or they had received the vaccine.

Overall, the enforcement does help the numbers go down. We could see this because the data creates a skewed data set towards the lowest enforcement level; showing that the lower the enforcement the less effective the lockdown will be.

## Significant Achievements

My significant achievement was creating this program by myself. To me it was a huge undertaking for the research I made over something that was constantly changing as new things had been discovered. Creating this program was my biggest programming project I've ever made and took a lot of perseverance to stay on task and to overcome problems I found along the way. I feel like I could have tweaked the program so that there would be a constant rate of people that would receive the vaccine.

## Acknowledgements

I would like to acknowledge Creighton Edington and Abe Anderson for helping me create the program by suggesting different things for me to look into to improve on the program. Creighton Edington has shown me how to program in NetLogo and has continued to teach me how to use NetLogo to make it easier for me to complete tasks or to conduct experiments. Abe Anderson has continued to support me throughout all of high school and has helped me conduct previous science fair projects.

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